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GEOGRAPHICAL DISTRIBUTION OF SOME AMERICAN POLYPORACEAE [1, 2]

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(WITH 30 FIGURES)

Plant Geography is a science of rather recent development. In the literature of this science the titles that deal with the distribution of fungi are few, and fewer yet are those which deal in terms of world wide distribution. The number of species of fungi supposedly known to science at the present time varies with the enumerator from around 60,000 if he is considering the hundreds of known and possible synonyms, to 100,000 if he be merely an enumerator of proposed names. Bisby has surmised that there are possibly 200,000 species of fungi on the earth. Although the number of species reported for North America in Seymour's Host Index is between 40,000 and 50,000 (fide Bisby), the range of the individual species is largely an unknown quantity except in a few groups, and furthermore the records presented in this host index involve only the parasitic fungi and those species of saprophytes that occur on dead plant and animal remains. At any rate the group is large enough to comprise a sizable section of any

[1] Address of the Retiring President of the Mycological Society of America, December 28, 1938, at the Richmond meeting of the American Association for the Advancement of Science.

[2] Authorized for publication on May 16, 1939, as paper no. 905 in the Journal Series of the Pennsylvania Agricultural Experiment Station. Contribution no. 119, Department of Botany, The Pennsylvania State College, State College, Pa.

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adequate consideration of the science of plant distribution. Information concerning world wide distribution of fungi must necessarily await the appearance of more or less comprehensive floras enumerating the species of the land areas of the world, and it must be admitted that fewer papers of a monographic nature have appeared for the fungi than for most other groups of comparable size. The distribution of species in the Family Polyporaceae is better known than in most other groups of fungi, and perhaps a beginning could be made in presenting the facts about world distribution of members of this group.

Bisby reports that 60 per cent of the species of fungi known to occur in Manitoba are also present in Europe. He concludes from these and other considerations that in general fungi have a wider distribution than do flowering plants, and cites the point that spores are more easily disseminated than seeds and, therefore, both land and water barriers are less effective in preventing distribution of fungi than they are for seed plants. He mentions other pertinent points in this respect, among which not the least important is the fact that in identifying fungi from the literature, if one finds a fungus which agrees in a few outstanding characters mentioned in the highly inadequate descriptions of most European fungi, he will be inclined to refer the fungus to that species, whereas later investigations may reveal that there are several other points on which there is a total lack of agreement. Therefore, the European name comes into use and it may be many generations before the correct situation is revealed and a more suitable name proposed. Of course, this is offset in part by the fact that no greater a discrepancy than an unreported host or a new geographical location is made the pretext for imposing a new name on the gullible mycological public.

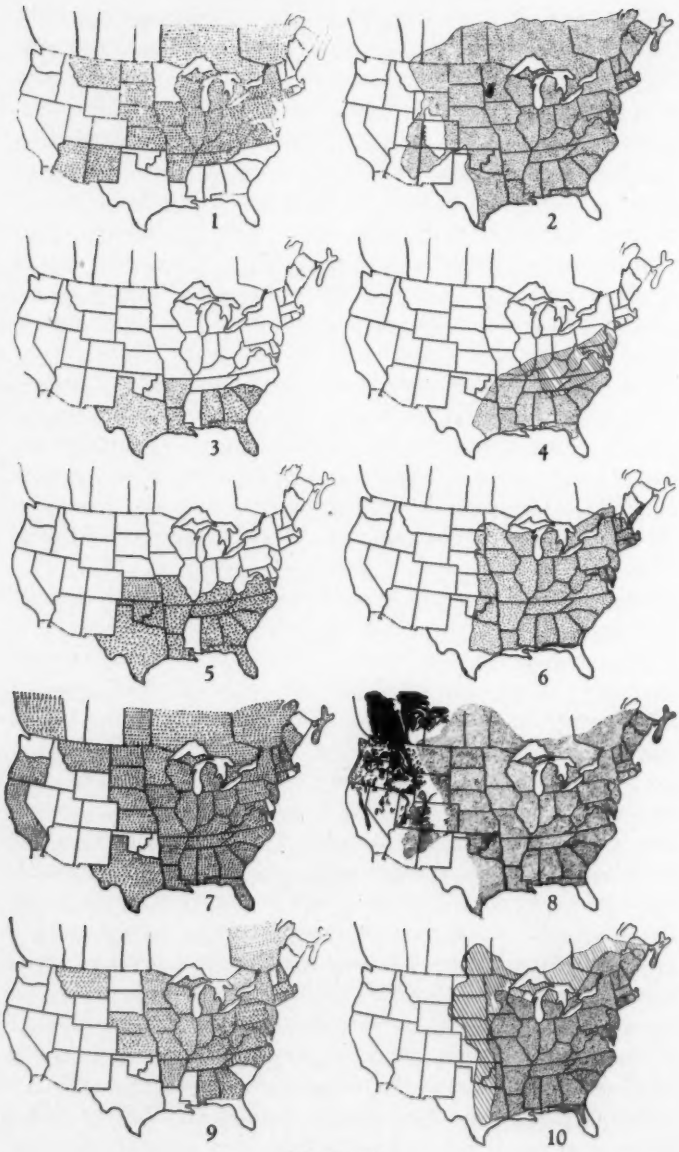
In the Polyporaceae it appears from my own results that at least 43 per cent of the approximately 227 species of American pileate Polyporaceae are known to occur in Europe or in other parts of the eastern hemisphere. Breaking the group down into genera we find that 54 per cent of the species of *Fomes,* 50 per cent of *Daedalea,* 54 per cent of *Trametes,* 50 per cent of *Lenzites,* and 44 per cent of *Polyporus* species of the United States and Canada are represented in non-American floras.

That many species of fungi have a wide distribution, cannot be doubted; yet, only in a few groups are generalizations made now likely to be upheld by future investigations. However this may be, a lack of uniformity in nomenclature, variations in interpretation of species concepts, and the added confusion introduced by the phenomenon of parasitism (together with the restrictions mentioned above) would still render hazardous any attempts at discussing the group from the viewpoint of world distribution.

In the preparation of a manuscript for a monographic treatise of the pileate polypores of the United States and Canada, I have resorted to a series of mapped distributions of individual species. It is only by use of aids of this sort that one secures, in the shortest interval of time, an adequate idea of the distribution of a species. An extensive list of states in which a species is known to occur must be scrutinized carefully in order to build up an adequate mental image of the details of geographical distribution. It is in connection with these distribution maps that I want to call attention to certain features of distribution of North American Polyporaceae in North America.

First, however, we must consider some of the factors that determine distributions in such a group of fungi as the polypores. It must be recalled, for example, that some of the species are terrestrial; others grow on dead wood; and still others grow on living trees. As to the terrestrial species of polypores, the factors that govern their distribution, though perhaps in the main known, have never been evaluated. As one studies distributional maps of such species it becomes clear that climatic factors must be important in this group. Of these factors undoubtedly temperature and moisture must be the predominating ones, although it is possible that light must not be disregarded and in all probability the distribution of some is influenced by the character of the surrounding vegetation which in turn influences the composition of the forest duff and the upper soil layers. For this particular group of polypores it seems to me that the factors that control distribution must primarily reside in about the same group of factors that is said to be of most importance in the distribution of phanerogams.

For the second and third groups above enumerated, *i.e.*, those growing on wood, including living trees, it is just as certain that



FIGS. 1–10.

the distribution of hosts and substrata must be of primary importance. That they are not the only factors involved is shown in a number of instances where the distribution of the fungus is not coextensive with that of the substrata. Thus *Juniperus virginiana* has a distributional range roughly from southern Maine to northern Florida and westward to eastern North Dakota and eastern Texas (FIG. 6). Yet *Polyporus pinsitus,* largely confined to this host but also occurring on a number of others with an even greater northern and western range, is known only from Virginia to Nebraska and southward (FIG. 5). It seems to me quite likely that temperature is the controlling factor in this instance, especially since the fungus extends to the western limits of its major host range but falls some 500 miles short of reaching the northern limits of that range. Another instance is that of *Daedalea quercina* which occurs principally on *Castanea dentata* and various species of *Quercus,* including *Q. alba,* but is known also on *Fagus grandifolia, Fraxinus americana, Juglans nigra, Ulmus americana,* and a few others. Except for Iowa, the present known distribution of the fungus is from Maine to North Carolina and west to New York and Ohio, while *Q. alba* ranges westward and northward to Wisconsin and Minnesota, and south to Florida and the Gulf States. The other hosts enumerated either are included in this range or extend only slightly beyond it. It may be questionable what the controlling factor is in this case, but it is definitely not host distribution. Other similar cases could be cited.

On the other hand, there are numerous cases where fungus and known hosts are almost identically distributed as would be expected if host range is the only determinant of distribution. Such a case is that of *Polyporus conchifer,* a species all but restricted to *Ulmus americana.* The range of the host in its native condition is across the eastern United States and southern Canada to Manitoba and Texas. The fungus actually surpasses the limits of this distribution in Montana (reported by Weir, perhaps on planted specimens of the elm), and is known to occur from Ottawa, Canada, to the Gulf states and west to Nebraska. Here again instances could be multiplied.

I have now indicated that there are cases in which climatic factors seem to govern distribution, and other cases in which the

range of the host is the only operative factor, sometimes with temperature as a secondary factor and sometimes without its effects being manifest. It might be pointed out, however, that in some cases where the fungus distribution seems to be controlled by the distribution of the host, it is after all temperature working through its effect on host that is actually the controlling factor.

In studying distributional maps of the polypores the idea occurred to me that in a group like this where there is considerable information as to distribution, yet a group in which much more remains to be learned on the subject, it ought to be possible to predict with some degree of success the eventual distributions of the species as they will be worked out in time.

Perhaps it may sound presumptuous when I say that I believe that after one spends the major portion of a lifetime in close contact with a rather small group of fungi, one gets an insight into the idiosyncrasies of the species that is not obtainable in the short span of, let us say, one's graduate study days. I believe that one gets a "feel" for the species that will often enable him to predict the behavior of these species under a given set of conditions. Everyone will agree that after handling a multiplicity of specimens, representing all degrees of development, undevelopment, and even decay, one attains a facility in the recognition of these species in their various guises that cannot be otherwise obtained. If such is possible in the field of identification, why is it not possible to develop such an understanding attitude that one can predict distribution?

Nor do I mean to say that the thought is entirely a new one. Undoubtedly every taxonomist has had to admit that after all a given extension to a geographical range is not so surprising when the known facts of distribution and host range are considered. At the same time, host distribution often accounts for the presence of a fungus in one state and its absence from an adjacent state, when one knowing only of its presence in the former instance is surprised to find it absent in the latter. Thus one can predict with some degree of assurance that *Polyporus amarus,* though occurring in California and Oregon, will not be found in Nevada nor in Washington, since its host is *Libocedrus decurrens.* In some cases one must take into account the fact that many species of

forest trees are planted more or less extensively in areas outside of their native range. Thus, while one is surprised to find *Polyporus conchifer* reported from Montana on *Ulmus americana,* yet when one considers that that tree species is widely planted in the United States, the report is at least credible.

That there are pitfalls in such a procedure is undeniable. The fact just mentioned concerning man's attempts at extending the range of host plants is one of them, and this might lead to the establishment of a species of fungus at long distances from its previously known range. Another is the question as to the authenticity of our records of host distribution. I have relied mainly for this information on a recently published series of distribution maps by E. N. Munns, of the United States Forest Service, published as U. S. Department Agriculture, Miscellaneous Publication no. 287, 1938. Some information I have secured from Sargent's Manual of the Trees of North America, of less use to me, however, because it does not give mapped distributions. Munn's distribution of *Ulmus americana,* for example, shows that the western limit of its range contacts but does not cross the eastern borders of Wyoming and Montana. Perhaps this may not be taken to indicate the entire absence of this species in either of those states. There may also be a question as to whether all of our fungus species (or even host species) have actually reached the limits of their ranges. Perhaps some of them have in comparatively recent times been introduced from other lands and have not yet had time to disseminate themselves as widely as will eventually occur. Particularly might this occur to a fungus species which found in its new environment a hitherto unused host capable of sustaining it. Predictions as to final distributional range might easily be wrecked in such an instance. Finally, one's ideas as to species limits may be shown to be too narrow or too broad in some cases which could not be matters of opinion.

In the making of the maps to illustrate the fungus distributions that I shall now discuss, I have had the advantage of having access to the leading herbaria of the eastern United States over a period of more than a score of years. I have received thousands of specimens from correspondents scattered over the United States and Canada. And finally I have myself collected extensively over the

area except the far West. In addition to this I have accepted the printed records of those whom I judge to have been competent namers of collections as such records have appeared in the literature. Obviously the early lists contain too many errors and discrepancies to be of much value. That all the records used in making the maps are without error is too much to hope. I shall illustrate this point with a single example. The species involved is *Daedalea ambigua*. According to my own records this species should not occur north of southern Ohio, Indiana and Illinois. Hence a recently reported record from "New Berne" New York looked suspicious, especially since no such locality could be found on any map nor in the U. S. Postal Guide. A letter to Dr. House at Albany, to whom the collection was credited, brought the information that the specimen was collected at New Berne, *North Carolina*. At the same time it had been noticed that Miss Wolf reported the same species from Iowa. A perusal of her paper shows, however, that she was including it only on the basis of an earlier report by Dr. MacBride, and she states that no specimen exists so far as she is aware. Hence I have excluded the state of Iowa from the known distribution of this species. This emboldens me to view with suspicion another northern record of the same species from Algoma, Wisconsin. Either of these last two might conceivably be true, but the facts of the distribution of the species based on specimens that I have examined argues against both of these records.

The maps as prepared have an additional flaw. In some cases a state is included on the basis of a single specimen; the map as presented, however, would seem to indicate the presence of the species throughout that state. Such an inference is not intended, but until more records for each state are available the distribution could scarcely be mapped more accurately. States which show a wide diversity of climate in different areas, or a wide diversity of topography, or a localization of host ranges within its borders are the ones, of course, in which one may expect discrepancies in fungous distributions. For example, many species are reported from the mountainous sections of Colorado that certainly do not occur in the high plateau region of the eastern part of the state. These differences are not reflected in the maps and it would appear

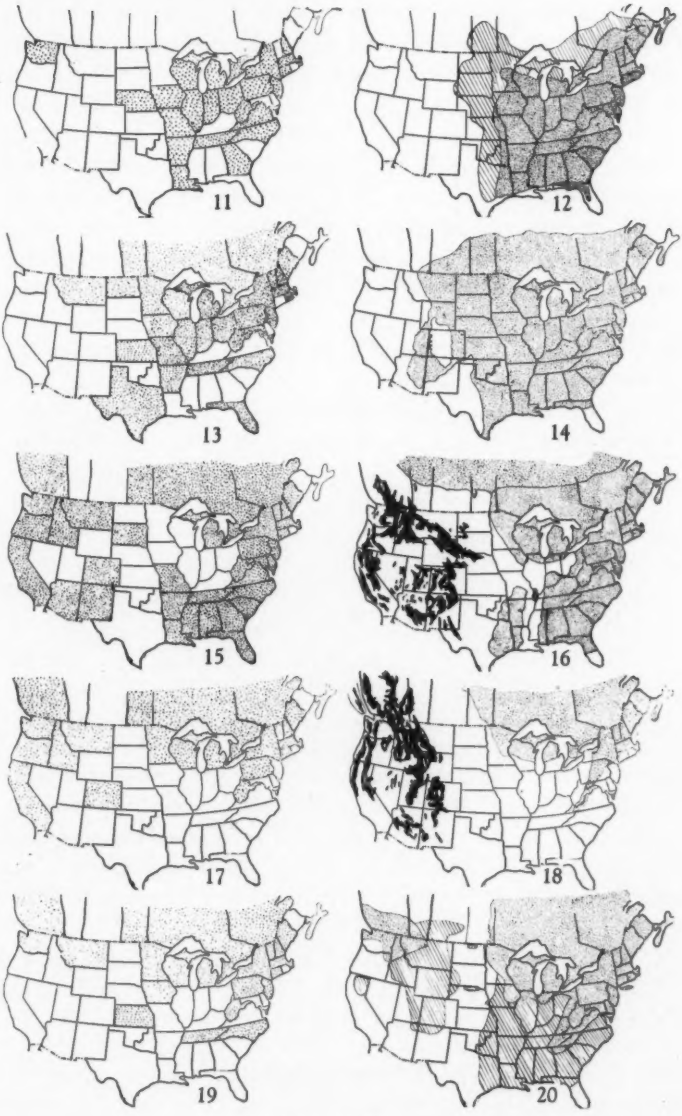
from them that the species occurs through the state. Species reported commonly from northern California may not occur in southern California at all; again this is not taken care of. To have limited the mapped distribution to those stations from which specimens have been examined or reported would be going to the opposite extreme.

It is, of course, not feasible to include in this paper all of the 200 species of polypores occurring in the United States and Canada. Actually only a few are considered and they are all wood-inhabiting species. Only enough species are included to indicate the feasibility of prognostications of this sort. Nor is the subject presented without the hope that yet another result may accrue. Many states are little known mycologically. For example, though the fungous flora of Rhode Island must be essentially the same as that of Massachusetts and Connecticut, yet the reader will note from the maps that no eastern state is so poorly represented in the distributions as is that one. Specimens from that state are not found in any number in any of the main herbaria of the East. Oklahoma fungi are likewise poorly represented in the larger herbaria as are also those of Arizona, New Mexico, Utah, and Nevada. I have not yet succeeded in obtaining a record of the occurrence of any species in every state of the Union. The closest approach is in the species *Polyporus adustus* for which specimens have been examined from every state except Utah and Nevada. and from all the Canadian Provinces except Saskatchewan. I have seen specimens or have what I consider to be authentic records of *Lenzites saepiaria* from all of the states except Rhode Island, Delaware, Oklahoma and Nevada. *P. versicolor* is lacking representation in Rhode Island, New Hampshire, Wyoming, Utah and Nevada, though I do not doubt that I have myself seen the species growing in both of the former states. *P. pargamenus* is represented in all but Nebraska, Arizona, and California. There is not the slightest doubt that each of these species occurs in every state in the union and every Canadian province. Is it too much to hope that as a result of calling attention to these and other unwarranted gaps in distribution that additional distributions may be secured? If every mycologist who is fortunate enough to spend time in any of the states from which no list of polypores has been presented

would collect even the most common species and send them to one of the larger eastern herbaria he or she would be making a definite contribution to our knowledge of the distribution of the species of this group. By way of illustration, I might add that in a small random lot of about a dozen collections picked up recently at my request by a non-mycological botanist of Oklahoma, six new records for that state were secured.

The optimum temperatures for growth of these fungi in pure culture, so far as determined at the present time, have been of no assistance in these prognostications. For example, the optimum temperature for *Fomes Pini* is given as 20° C., and for *Lenzites saepiaria* as 36° C., the former classed by Humphrey and Siggers as a low-temperature organism and the latter as a high-temperature organism. These facts are not reflected in the distribution of the species. Both occur from Canada to Florida and both will eventually be known from every state in the Union and from all of the Canadian provinces. Likewise *Daedalea ambigua* and *Lenzites Berkeleyi* are classed in the intermediate temperature group by Humphrey and Siggers. Yet both are southern in distribution, the latter being practically confined to the Gulf States. Moreover it is easily conceivable that two fungi as different in their optima as *Fomes Pini* (20° C.) and *Lenzites saepiaria* (36° C.), one inhabiting living trees and the other on dead and down timber in exposed situations, might both be growing at their optima though separated from each other by distances of but a few feet and hence exposed to the same climatic factors of the atmosphere. After all it is the conditions that exist within the substratum that must be in the main the determining factors. For example, regardless of the air temperature, the temperature within an old log or piece of slash might approach the optimum for the latter species while the temperature within the living tree might be just as close to the optimum for the former. And even further, it may well be that factors inherent in the substrate itself may shift the optima. After all, the optima as determined by the growth of fungi in pure culture are for those fungi growing under a definite set of conditions that may fall far short of representing the conditions under which the fungus naturally grows.

Space does not permit the incorporation of maps of several spe-



FIGS. 11–20.

cies on which predictions were made in the preparation of this paper. Hence, about a third of the species discussed are without distributional maps of both fungus and hosts.

With the preceding considerations in view we may now proceed with some predictions concerning distribution of species. The procedure is simple. The distribution of a given species as known at the present time is mapped. From among the species of trees which are known to give suitable substrates for this fungus, there is selected one or more species whose combined ranges overrun (if possible) the known range of the fungus. The two maps are then compared. Reference to the maps representative of *Fomes fraxinophilus* (FIGS. 1, 2) may make this clear. All of these maps are presented in pairs, figures 1 and 2 representing one species, 3 and 4 another species, etc. The range map for the fungus is in each case on the left, the host range map on the right. By comparing figures 1 and 2 conclusions are drawn as follows: (1) the fungus is undoubtedly present in Minnesota; (2) it should eventually be found in New Jersey, Delaware and Maryland; (3) since it is recorded from Quebec and from New York and Connecticut it will also eventually be found in all of the New England states and in New Brunswick and Nova Scotia, although its rarity in Pennsylvania, New York and Quebec as compared with its abundance in the middle-west indicates that it may require considerable search before it is located in any of those regions; (4) to the south its general absence so far from the Gulf states indicates that little can be expected from that region although suitable hosts are not lacking. In other words, the fungus is probably temperature-limited to some extent and this may be the factor operative in both the New England and the Gulf states region; (5) to the westward it should eventually be found in Oklahoma, Colorado and Wyoming and also farther north in Manitoba. The center of distribution of this fungus being in the upper Mississippi and Ohio River valleys, it is not likely that in any of the outlying regions mentioned it will prove to be at all common.

DAEDALEA AMBIGUA

This species is at present known to occur from Ohio and Illinois south to the Gulf of Mexico. It occurs on a variety of hosts in-

cluding *Diospyros, Celtis, Quercus, Ulmus, Acer* and others. Its present range corresponds roughly to the range of *Diospyros virginiana,* which is one of its more frequent hosts. All of its other hosts overrun this range. The fungus will, of course, be found in Kentucky, Virginia, Maryland and Delaware. In addition to these states I do not believe its range will ever exceed that now known except possibly for southeastern Pennsylvania and southeastern Nebraska. Hence, although the hosts on which it occurs extend considerably beyond its known range it is probably again a species limited by some climatic factor, of which temperature is the most likely.

FOMES CONCHATUS

Consideration of the known distribution of the fungus (FIG. 13) and of its *Fraxinus* hosts (FIG. 14) indicates that the fungus will most certainly be found in New Brunswick, Nova Scotia, Connecticut, Delaware, Virginia, Kentucky, Oklahoma, Nebraska, South Dakota, Alberta and Saskatchewan, and possibly in South Carolina, Georgia, Alabama, Mississippi, Louisiana, New Mexico, Arizona, Colorado, Utah and Wyoming. This assumes that Lloyd's record of the species from Florida is correct. Otherwise the fungus may be somewhat temperature limited in the southeast. The fact that the fungus is known on nearly 20 genera of hardwoods besides *Fraxinus,* is additional evidence of its wide range. The fact that it has never been collected in Colorado may indicate that it may be rare westward.

FOMES EVERHARTII

F. Everhartii occurs generally over the eastern half of the United States (FIG. 9). Its hosts comprise most of the species of *Quercus* and in addition a variety of common hardwoods of other genera, including *Carya, Fagus, Juglans, Liriodendron,* and *Ulmus,* but these last named hosts are only occasionally used. The distribution of its combined *Quercus* hosts is shown in figure 10. Few of the other hardwoods which it uses surpass the range of the *Quercus* hosts, and since it does not cover the range of the latter hosts the others can be of little importance. Considering these facts, I expect it to eventually be collected in Vermont, South Carolina, Mis-

sissippi, Oklahoma, North and South Dakota, and in Quebec. If *Fomes dependens* and *F. praerimosus* be considered forms of this species, the range will be extended to Florida, Texas, New Mexico, and Arizona and possibly Utah and Colorado.

FOMES FRAXINEUS

This is a rare species known from about nine states from New York to Florida and Louisiana. It occurs usually on species of *Fraxinus*, on *Acer Negundo*, on *Nyssa sylvatica* and on *Ulmus*, but nowhere outside the distribution of *Fraxinus americana*. The fungus should eventually be found in lower Ontario and from all of the states east of the Mississippi River.

FOMES FRAXINOPHILUS

The center of distribution of this fungus is in the Mississippi and Ohio River valleys. Outside of this area it is rare, but is known to occur (FIG. 1) from Quebec to Virginia and west to Montana and Arizona. This does not include the distribution of *F. Ellisianus* which is sometimes regarded as a variety. The species is found almost exclusively on *Fraxinus* but has been reported on *Platanus, Quercus, Ulmus* and *Salix*. The range of acceptable hosts is shown in figure 2. I believe the fungus is to an extent temperature limited since it has been found in none of the Gulf states. It should occur through the northeastern section of the country and will be found in New Jersey, Delaware, Maryland, North Carolina, Oklahoma, Colorado, Wyoming, Minnesota and in Manitoba.

FOMES PINI

Although this is usually described as a cosmopolitan species in the northern hemisphere, there are no exact records of its distribution in the United States. The map for the species (FIG. 21) shows that there are records of its occurrence generally throughout the United States and Canada. Figure 22 shows that its hosts are present in every state in the Union except Kansas, and Bartholomew's list includes the fungus from that state though he does not name the host. There can be no question but that the species occurs in every state and province.

FOMES FULVUS

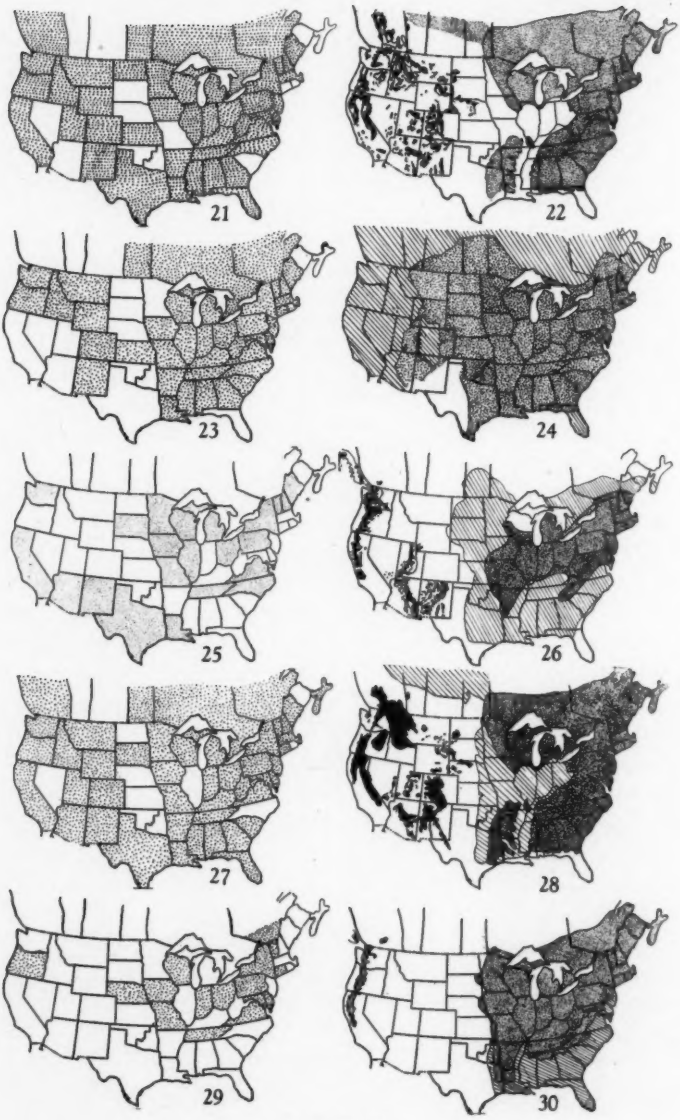
The known distribution of this fungus is a bit irregular but it appears to be well scattered over the country east of the Rocky Mountains. It is not a common species, except perhaps locally. The matter of its hosts has not been accurately determined. It is practically confined to the wild plum species of the genus *Prunus,* being reported mainly on *P. americana* and *P. nigra,* which together account for the known range of the fungus. From its range map one could predict with considerable confidence that the final distribution of the fungus will include also Quebec, Vermont, New Hampshire, New York, New Jersey, Delaware, Florida, Mississippi, Louisiana, Texas, Arkansas, Oklahoma, Illinois, Wisconsin, South Dakota, and Wyoming.

LENZITES BETULINA

This is one of the more widespread of the species of polypores (FIG. 7). It occurs on more than 20 genera of hardwoods, and is known from practically the whole of the United States except in the western mountains from Idaho to New Mexico. Figure 8 is sufficient to show that among its hosts are species known from every state in the union and from all of the Canadian provinces. *Fraxinus pennsylvanica lanceolata, Prunus serotina,* and *Populus tremuloides* are such hosts. Nevertheless the fungus must be extremely rare in that area from which it is not yet known, since Shope does not report it in his extensive studies of Colorado Polyporaceae, and neither Kauffman nor myself found it in extensive collecting in the same state. Nevertheless I predict that it will eventually be found in every state in the Union and in all of the Canadian provinces. In the East, only Delaware, Rhode Island, and New Brunswick are without records of it, but, of course, these gaps will eventually be filled. In northern Ontario and Quebec the host is usually a species of *Betula* and on the west coast *Quercus* more frequently serves.

POLYPORUS ABIETINUS

Polyporus abietinus is one of the most widespread and abundant species of all of the polypores. Its known distribution is shown



FIGS. 21–30.

in figure 27. It inhabits all species of conifers. Since there are one or more species of conifers in every state in the Union (FIG. 28), and since it seems to have little in the way of climatic inhibitions, there can be little doubt that the remaining states of Rhode Island and North Carolina (in both of which I have undoubtedly seen it growing myself), Illinois, Oklahoma, Kansas, Nebraska, North Dakota, and Nevada will eventually produce it as will New Brunswick, Alberta and Saskatchewan.

POLYPORUS AMARUS

P. amarus is the fungus causing the defect in *Libocedrus decurrens* known as "pin rot." It is practically confined to that host, but at the Brooklyn Botanic Garden there is a specimen collected by Hubert on *Abies grandis* in Idaho. Except for the Idaho station the distributions of host and fungus agree, and if the fungus were at all common on *Abies grandis* or any other western conifer this fact would have been discovered in the extensive work done on timber decay fungi in that region, for though sporophores are seldom collected, due to their early succumbing to the ravages of beetles, yet the rot is highly characteristic and easily recognized. Boyce reports a similar decay in western red cedar but states that it is not known to be caused by this fungus. Hence, I conclude that the general range of the fungus is now known. It is to be regarded as a host-limited species though its local distribution may possibly be governed by other factors.

POLYPORUS BALSAMEUS

P. balsameus is a species limited both in geographical range and in its host species. The species is confined to the cooler regions of the northeast, ranging south in the mountains to Tennessee and North Carolina. The map showing the distribution of *Abies balsamea,* its chief host, is almost of identical outline with the known distribution of the fungus. Its chief minor host is *Tsuga canadensis.* The fungus should eventually be found in New Brunswick, Maine, New Hampshire, Vermont, western Massachusetts, Maryland, West Virginia, western Virginia, eastern Kentucky and in Manitoba. It probably will also be found in the balsam fir region of Saskatchewan, Alberta and British Columbia.

POLYPORUS BETULINUS

P. betulinus is a rather widespread species in the northern United States and Canada but with a rather discontinuous distribution (FIG. 19). It occurs only on species of *Betula,* especially *Betula papyrifera, B. populifolia, B. lenta,* and *B. lutea* in that order of frequency in the east and on *B. papyrifera* var. *occidentalis* in Montana. It has not been reported on *B. fontinalis* which ranges southward in the Rocky Mountains to Arizona and New Mexico, nor on *B. nigra.* Since within the range of this species and the variety mentioned rather intensive collecting has failed to produce it, I conclude that it will not be found in southern states where *B. nigra* overruns the limits of its more acceptable hosts nor in the west in that region where *B. fontinalis* exceeds the range of known acceptable hosts. It is undoubtedly present in New Brunswick, Rhode Island, Delaware and Maryland, and probably also in Virginia, Kentucky, northern Illinois and Indiana, and possibly in Ohio, Idaho, and Alberta. Bartholomew reports it from Kansas and so far as I can find, *Betula nigra* is the only host native to that state, although possibly *B. papyrifera* or one of its varieties may be planted extensively. As a matter of fact, the Kansas record does not sound plausible.

POLYPORUS CINNABARINUS

Although this species is usually regarded as universal in distribution in the northern hemisphere where any hardwood substrata at all are present, there appear to be 11 states from which it has not been reported (FIG. 24). And though these are somewhat grouped, it indicates undoubtedly a lessened population rather than a total absence of the species, especially since the fungus does occasionally occur on coniferous wood. As shown in the map (FIG. 25) it takes the combined distributions of but two substratal species, *Fraxinus pennsylvanica lanceolata* and *Populus tremuloides,* to cover the entire range of the United States and Canada. There is no reason to suppose, therefore, but that *P. cinnabarinus* occurs in every state in the Union and every province in Canada. If more evidence as to the possibility of its occurrence in the arid southwest were desired it might be pointed out that it is distinctly a xerophytic type of fungus and is already known from New Mexico.

POLYPORUS CONCHIFER

P. conchifer, although reported a number of times on hosts other than *Ulmus americana,* is nevertheless practically confined to that species of host. Although perhaps less common southward the fungus has been widely reported from North Dakota and Kansas eastward—a range that is covered almost in its entirety by the range of the host. Moreover the host is widely planted for shade and ornamental purposes. This may account for Weir's report of the fungus from Montana, since distribution maps do not indicate the presence of the host in that state. There can be little question that the fungus will eventually be reported from New Brunswick, Nova Scotia, North Carolina, South Carolina, Florida, Mississippi, Louisiana, Texas, Oklahoma, and South Dakota, *i.e.,* the fungus will eventually be known from the entire range of the host and possibly from some states where the host is not native but is widely planted.

POLYPORUS CROCEUS

P. croceus is known from New York to Florida and west to Minnesota and Arkansas. Its hosts are *Castanea dentata* and various species of *Quercus.* The host range of *Quercus alba* nicely covers the range of the fungus as at present known. Both on the north and the west acceptable hosts overrun the range of *Q. alba* but I predict that the range of the fungus will not be extended to cover much of this host range. It will, however, be finally reported from New Jersey, Maryland, Georgia, Alabama, Mississippi, and Louisiana, and probably in eastern Oklahoma and Texas; probably also in southern Ontario.

POLYPORUS DELECTANS

P. delectans occurs on half a dozen hardwood genera, more commonly on *Acer* than others which include *Carya, Fraxinus, Juglans, Populus* and *Quercus.* The known range of the fungus is shown in figure 29, mainly eastern but quite scattered. The range of *Acer Saccharum* covers the fungus range. Other acceptable species of host occur on the south (FIG. 30). The fungus is considered to be temperature-limited, however, since it does not reach the southern limits of its main host (*A. Saccharum*). The fungus should yet

be found in New Brunswick, Nova Scotia, Maine, New Hampshire, Massachusetts, Rhode Island, New Jersey, West Virginia, Kentucky, Illinois, Michigan, and Minnesota; possibly in North Dakota, South Dakota, Kansas and Arkansas.

In the west it is known to occur on *Quercus*, probably *Q. Garryana*. It should occur also on that host in Washington and perhaps California.

POLYPORUS DRYOPHILUS

Few species have as wide a range as this. It is known throughout the United States except in the Gulf States and the Central West (FIG. 25). It has not been recorded from Canada. Its hosts are various species of oaks and in addition it has been collected on species of *Acer, Fagus, Prunus,* and *Schinus*. There is a variety on *Populus* which is not here included. The combined range of but a few of its hosts would cover the known range of the fungus in the states as far west as the Dakotas (FIG. 26). Various species of *Quercus* are found in practically all parts of the United States and in eastern Canada. Idaho and Montana seem to be states outside the range of oaks—hence the fungus can hardly be expected there. The fact that it has not yet been reported from Canada indicates that not much can be expected from that region in the future, although it probably will be found in lower Ontario and Quebec. Otherwise it should eventually be collected in Massachusetts, Connecticut, Rhode Island, New Jersey, Delaware, West Virginia, Maryland, Kentucky, Indiana, Arkansas, Mississippi, Oklahoma, North Dakota and Utah. The var. *vulpinus* is already known from Quebec and Ontario.

POLYPORUS FIBRILLOSUS

P. fibrillosus is rather widely distributed (FIG. 17) in the northern states and Canada on *Abies, Picea, Larix, Tsuga* and *Pseudotsuga*. In the east its range corresponds almost exactly to that of *Abies balsamea* and in the west the range of *Pseudotsuga* overruns the range of the fungus (FIG. 18). From a consideration of these maps I predict that the fungus will eventually be found also in Nova Scotia, New Brunswick, Nevada, Utah, Wyoming, Alberta, and Saskatchewan, and possibly in the high mountains of western

Virginia, western North Carolina, and eastern Tennessee. Since there are also acceptable pine substrata in North Dakota and South Dakota, it will also likely be found in those states.

POLYPORUS GUTTULATUS

This is a characteristic species of the northern and cooler coniferous forests, widely distributed except in the south and in the western plains country. In the east its range is practically that of the combined ranges of *Abies balsamea* and *Tsuga canadensis* which are favorite hosts, though the fungus occurs also on species of five other genera of conifers and occasionally on hardwoods. In the east it should yet be found in New Brunswick, Nova Scotia, Connecticut, Rhode Island, New Jersey, Maryland and West Virginia. In the west its range approximates that of *Pseudotsuga taxifolia* and it should yet be found in Alberta, northern Saskatchewan, Montana, Wyoming, Colorado, Nevada and Utah; possibly in Arizona and New Mexico.

POLYPORUS LUDOVICIANUS

This is a southern species. The known range outside of the Gulf States (FIG. 3) includes only Arkansas, Georgia and South Carolina. It occurs on various species of *Quercus* and perhaps even more commonly on *Liquidambar styraciflua*. Its range as known at present corresponds closely to the range of *Q. nigra* (FIG. 4) on which it occurs. The limits of other species of *Quercus* and of *Liquidambar styraciflua* overlap that of *Q. nigra* and extend northward and (in case of some of the oaks) westward. Yet except for Mississippi and possibly eastern Oklahoma, I predict that the range of the fungus will not be extended by future collectors. It is apparently a species that is limited by temperature.

POLYPORUS PINSITUS

Reference has already been made to this species as one whose known range falls considerably short of equalling the range of its usual host, *Juniperus virginiana*. That the distribution shown on the map (FIG. 5) is approximately correct for its actual range is indicated by the fact that the only gap in the range over which it

has been collected is the state of Mississippi. The indications are, therefore, that some factor other than host range (FIG. 6) is limiting the range of the fungus. I take this factor to be in all probability concerned with temperature. I would consider, therefore, the state of Mississippi as the only certain addition to the list of states, with the hint that southern Illinois and southern Indiana would be worthy of further exploration in its behalf. A number of southern species extend their range up the Mississippi River Valley. To the west it is possible that it may yet be found in New Mexico and Arizona since it has been collected on *Prosopis* in Texas at the edge of the range of *Juniperus,* and *Prosopis* ranges even farther westward.

POLYPORUS SCHWEINITZII

Here again we have a species of wide distribution, already known from all of the principal conifer regions of the United States and Canada (FIG. 15). In other words, it appears to have no pronounced climatic limitations. It appears to attack all genera of coniferous trees except *Juniperus* and, therefore, finds suitable substrata in every state and province except Kansas (FIG. 16). Therefore the fungus should eventually be found in every state of the Union except possibly Kansas and Nebraska, and from all of the Canadian provinces.

POLYPORUS SPRAGUEI

A species well distributed through the eastern half of the United States (FIG. 11). A collection was made by Faull at Toronto, Ontario, and Zeller has reported it from Washington. I have not seen this last specimen. It occurs on a variety of species of *Quercus* and more rarely on other hardwood genera. The range of *Quercus alba* (FIG. 12) covers its distribution as now known. Other acceptable species of *Quercus* overlap the present known range of the fungus, however. I predict future additions to the range from Vermont, Rhode Island, Maryland, Delaware, South Carolina, Alabama, Mississippi, Florida, eastern Texas, eastern Oklahoma, Kentucky, Minnesota, North and South Dakota, and probably southern Quebec.

POLYPORUS TEXANUS

This is a species of the far southwest, known at present only from Texas and Arizona. The host is *Prosopis juliflora,* one of the mesquites of that region. There is no reason to suppose that the fungus does not occur in New Mexico and probably in Oklahoma. *Prosopis pubescens* is another species of the region reaching sizes sufficiently large to provide a substratum. The fungus has not been reported on this host but very likely will be found on it and there is a strong possibility that the range will be extended to Utah, Nevada, and California. Even Nebraska and Louisiana are likely eventually to be found to be within its range. Since it has been reported on no other host, the species is probably host-limited in its range.

SUMMARY

This paper is an attempt to predict the eventual range of certain species of pileate Polyporaceae in the United States and Canada. The procedure has been to compare maps showing the present known range of each species of fungus with maps showing the distribution of the major hosts or substrata. From these, predictions are made, both as to the filling of gaps in our present knowledge of distribution and as to the possible extensions of ranges that the future will disclose. The relation of certain climatic factors to distribution are briefly discussed. Some of the pitfalls of such a procedure are pointed out.

Attention is called to the fact that our herbaria could be greatly enriched from this standpoint if more local collectors would send in specimens. Also collections of species from states and provinces where gaps are indicated would be most welcome to the writer.

EXPLANATION OF FIGURES

Fig. 1, known distribution of *Fomes fraxinophilus.* 2, combined ranges of *Fraxinus nigra* and *F. pennsylvanica lanceolata.* 3, known distribution of *Polyporus ludovicianus.* 4, distribution of *Quercus nigra* and *Liquidambar styraciflua.* The hatching indicates the range of the latter beyond the former species. 5, known distribution of *Polyporus pinsitus.* 6, range of *Juniperus virginiana.* 7, known distribution of *Lenzites betulina.* 8, combined ranges of four species of hardwoods which together give acceptable substrata for *Lenzites betulina* in every state and province. The species

included are: *Carya cordiformis, Ulmus americana, Populus tremuloides,* and *Fraxinus pennsylvanica lanceolata.* 9, known distribution of *Fomes Everhartii.* 10, combined ranges of *Quercus alba* (stippled) and *Q. macrocarpa,* two acceptable substrata for *F. Everhartii.* 11, known distribution of *Polyporus Spraguei.* 12, combined ranges of *Quercus alba* (stippled) and *Q. macrocarpa,* both acceptable substrata for *P. Spraguei.* 13, known distribution of *Fomes conchatus.* 14, combined ranges of *Fraxinus nigra* and *F. pennsylvanica lanceolata,* substrates for *Fomes conchatus.* 15, known distribution of *Polyporus Schweinitzii.* 16, combined ranges of *Pinus taeda, P. echinata, P. Strobus,* and *P. ponderosa,* indicating suitable substrata for *P. Schweinitzii* in every state and province except Kansas. 17, known distribution of *Polyporus fibrillosus.* 18, range of *Abies balsamea* in the east and *Pseudotsuga taxifolia* in the west, both suitable substrata for *Polyporus fibrillosus.* 19, known distribution of *Polyporus betulinus.* 20, range of *Betula lutea, B. papyrifera,* and *B. nigra* in the east and *B. papyrifera occidentalis* and *B. fontinalis* in the west. *Polyporus betulinus* is not known to occur on either *B. fontinalis* or *B. nigra.* 21, known distribution of *Fomes Pini.* 22, range of *Pinus Strobus* and *P. echinata* in the east, and of *P. ponderosa* in the west, the two ranges connected in northern Canada by the ranges of several coniferous species including *Pinus Banksiana, Larix laricina,* etc., giving a suitable substratum for *Fomes Pini* in every state and province except Kansas. 23, known distribution of *Polyporus cinnabarinus.* 24, combined ranges of *Fraxinus pennsylvanica lanceolata* and *Populus tremuloides,* both acceptable substrata for *Polyporus cinnabarinus.* 25, known range of *Polyporus dryophilus.* 26, range of various species of oaks in the eastern half and of several western species, giving suitable substrata for *Polyporus dryophilus* in all the states except possibly Idaho, Montana, and Colorado, although not reported on all of the hosts here included. 27, known range of *Polyporus abietinus.* 28, range of various coniferous species all of which are acceptable hosts for *Polyporus abietinus,* thus giving suitable substrata in every state and province. 29, known range of *Polyporus delectans.* 30, combined ranges of *Acer rubrum, A. Saccharum* in the east and of *Quercus Garryana* in the west, all of which are suitable substrates for *Polyporus delectans.*

THE ASPERGILLUS NIDULANS GROUP

CHARLES THOM & KENNETH B. RAPER

(WITH 6 FIGURES)

Aspergillus (*Sterigmatocystis*) *nidulans* was described by Eidam in 1883. Since that time the general type of organism covered by his diagnosis has become fairly well known and certain striking characters have become recognized as defining a number of cosmopolitan strains or species, commonly referred to as constituting the *Aspergillus nidulans* group. These characters are as follows: (1) Short columnar heads (FIG. 5*D*) with primary and secondary sterigmata (FIG. 1*C*); (2) smooth walled conidiophores (FIG. 1*C*) more or less browned, usually sinuate (FIG. 1*B*), commonly less than 200 μ long and terminating in dome-like or hemispherical vesicles (FIG. 1*C*); (3) small echinulate conidia 3–4 μ in diameter; (4) brittle perithecia with walls of one cell thickness; (5) quickly ripening ascospores, purple-red in color, and with equatorial banding (FIG. 4); and (6) large, thick walled, globose bodies, termed "hülle cells" by Eidam (FIG. 1*D*), forming an irregular layer about the perithecia (FIG. 3).

In germination the ascospores of this group, like those of the *Aspergillus glaucus* (or *Eurotium* group), swell and the wall splits into two halves or "valves" along the equatorial line. Since they are red in color, the valves stand out conspicuously on opposite sides of the developing germ tube.

Wehmer in 1901 incorporated Eidam's description into his survey of *Aspergillus*, without acquaintance with the species in culture, placing it among his section *Microaspergilli* on account of the measurements of the conidial apparatus in contrast to those of such large species as *A. niger*.

Thom and Church in 1918 recognized striking variations among ascospores in strains showing the general characters of *A. nidulans* but did not propose changes in nomenclature. The same discussion was repeated in their monograph of the *Aspergilli* in 1924. In the

intervening period, many more strains of this group have been examined in culture. Careful study of the ascospores and correlation of ascospore and colony characters convince us that the series contains at least 5 species and one or more varieties which

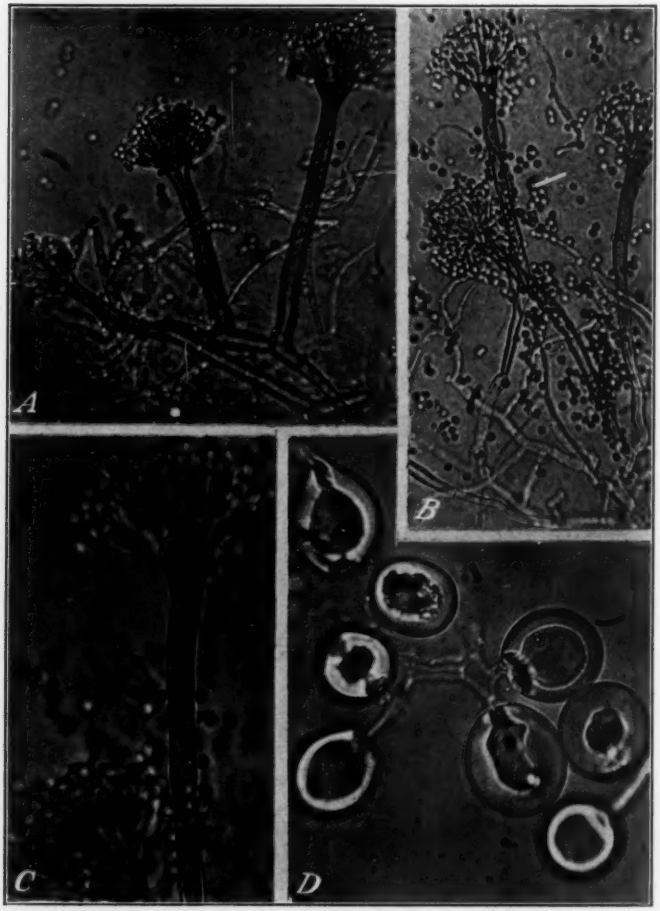


FIG. 1. *A* and *B*, conidial fructifications of *Aspergillus nidulans* showing the general character of the heads and conidiophores and the manner in which they arise from the vegetative mycelium, × 370; *C*, conidial head showing sterigmata in two series, hemispherical vesicle and smooth conidiophore, × 740; *D*, sterile, thick walled, hülle cells.

are readily distinguished by microscopic examination. Only organisms in our culture collection are included in this study. The designation "*A. nidulans* series" remains justified because of the basic characters common to all of the forms studied.

Consideration as to what section of this large series of related organisms should carry the name *A. nidulans* has led to the selection of a group of strains with smooth walled ascospores bearing narrow crests (FIG. 4*A*) and commonest among the members of the group as judged by frequency of occurrence among the cultures examined. One can hardly suppose that so good an observer as Eidam would have failed to note the rough walls on some spores (FIG. 4*C*), very wide crests on others, or the stellately lacerated crests of *A. variecolor* (FIG. 4*D*), had these been present.

All of the strains encountered in the group have grown well in Czapek's solution agar.[1] Other media likewise support good growth, but present different cultural pictures. When, for example, malt agar was used, the mass of conidial heads was greatly increased. Upon potato-dextrose the culture picture was intermediate between the two. When 20 per cent sucrose was used in Czapek's basal solution there was a great increase in vegetative mycelium but little increase in conidial or perithecial development. However, since these media offered no advantages over Czapek, that formula was used in the comparative work reported here.

The series has been arranged into an arbitrary key as follows:

Ascospores present
  Ascospores smooth walled
    Equatorial ridges two in number
      Ridges 0.5–1.0 μ wide, margin entire
        Conidial heads green ..... *A. nidulans*
          No. *4640.5* and others
        Conidial heads white ..... *A. nidulans* mut. *albus*
          No. *5616.2*
      Ridges 1.5–1.8 μ wide, margin entire ..... *A. nidulans* var. *latus*
        No. *110*
      Ridges 3.0 to 4.0 μ wide, margin dissected, starlike
        A. variecolor
        Nos. *5602.3* and *5667.498*
    Equatorial ridges four in number ..... *A. quadrilineatus*
      No. *4138.N8* and others

[1] Czapek's solution agar: Water 1000 cc., sodium nitrate 3 gms., dibasic potassium phosphate 1 gm., magnesium sulfate 0.5 gm., potassium chloride 0.5 gm., ferrous sulfate 0.01 gm., sucrose 30 gms., and agar 12.5 gms.

Ascospores rough walled ..... *A. rugulosus*
No. *4138.T11* and others
Ascospores lacking ..... *A. unguis*
No. *5076.1* and others

ASPERGILLUS NIDULANS (Eidam) Wint. in Rab. Krypt.-Fl. 1²: 62. 1884.

Syn. *Sterigmatocystis nidulans* Eidam in Cohn, Beitr. Biol. Pflanzen **3**: 392–411. *pl. 20–22.* 1883.

Colonies upon Czapek's solution agar plane, spreading broadly, dark cress green (Ridgway, Pl. XXXI) from abundant conidial heads during the first two weeks (FIG. 2*A*); perithecia developing from the center of the colony outward after the first few days, separately produced, often abundant; sectoring occasional; reverse of colony in varying shades of purplish red during the growing period, becoming very dark in age. Heads short, columnar, ranging from 40 to 80 μ by 25–40 μ, commonly 60 to 70 by 30 to 35 μ; stalks commonly sinuous (FIG. 1*B*), with walls smooth (FIG. 1*C*), in shades of cinnamon brown, ranging from 60 to 130 μ, commonly 75 to 100 μ in length, about 2.5 to 3 μ near the foot, increasing to 3½ to 5 μ below the hemispherical vesicle (FIG. 1*C*); vesicle 8 to 10 μ in diameter; sterigmata in two series (FIG. 1*C*), primary 5 to 6 by 2 to 3 μ and secondary 5 to 6 by 2 to 2.5 μ; conidia globose, rugulose, 3 to 3.5 μ in diameter, green in mass.

Perithecia developed separately within or upon the conidial layer (FIG. 2*A*), globose, ranging from 100 μ to 175 μ in diameter, commonly 125–150 μ, with outer layer a yellowish to cinnamon colored envelope of scattered hyphae bearing hülle cells up to 25 μ in diameter; wall composed of one layer of cells, dark reddish purple; in ripening becoming a mass of 8-spored asci which break down quickly leaving the ascospores free. Ascospores purple-red, lenticular, smooth walled with 2 equatorial crests (FIG. 4*A*), spore bodies about 3.8 to 4.5 μ in length by 3.5 to 4 μ in breadth, equatorial crests plaited with margin sinuous and entire ranging from 0.5 to 1 μ in width (Table I).

Diagnosis based primarily upon culture *4640.5* obtained from the Bainier collection in Paris. Other strains assigned to Eidam's species included many isolations from American soil and decaying vegetation, as well as cultures from European contributors. Common.

The range of ascospore measurements found in the cultures compared is shown in the accompanying table.

TABLE I

ASCOSPORE VARIATION IN STRAINS OF *Aspergillus nidulans*

Culture number	Overall dimension of spores	Width of crests	Dimensions of spore bodies
5541.L29	6.2–6.6 × 3.6–3.8 μ	1.0 μ ±	4.2–4.6 × 3.6–3.8 μ
4673	6.0–6.6 × 3.6–3.9 μ	1.0 μ ±	4.0–4.6 × 3.6–3.9 μ
5167	6.0–6.4 × 3.6–3.8 μ	1.0 μ ±	4.0–4.4 × 3.6–3.8 μ
5616.1	5.4–5.8 × 3.6–3.8 μ	0.6–0.8 μ	4.0–4.4 × 3.6–3.8 μ
5616.2[2]	do	do	do
5357.P10	5.4–5.8 × 3.6–3.9 μ	0.6–0.8 μ	4.0–4.4 × 3.6–3.9 μ
4640.5	5.4–5.8 × 3.6–3.8 μ	0.7–0.8 μ	3.9–4.3 × 3.6–3.8 μ
5335.169	5.0–5.6 × 3.7–4.0 μ	0.5–0.6 μ	3.9–4.5 × 3.7–4.0 μ
5456	5.0–5.4 × 3.6–3.8 μ	0.5–0.6 μ	4.0–4.4 × 3.6–3.8 μ
B-368	4.8–5.4 × 3.6–3.8 μ	0.5–0.6 μ	3.8–4.4 × 3.6–3.8 μ
B-480c	4.8–5.2 × 3.6–3.8 μ	0.5 μ ±	3.8–4.2 × 3.6–3.8 μ

[2]White mutant from culture No. 5616.1; described by Yuill as *Aspergillus nidulans* mut. *albus*.

In assigning Eidam's species name to the members of this series it is obvious that there are discrepancies. He described the perithecium as having a firm almost sclerotioid wall, whereas the wall is found to contain but one layer of cells. He figured the asci as few and scattered in a mycelial matrix within which ascospore production occupied many weeks. One isolated strain in our collection produces asci in this manner. For it a varietal name, *A. nidulans* var. *latus,* is here proposed on account of very broad crests on the ascospore in contrast to the usual types in *A. nidulans* which come much more closely to those indicated in Eidam's figures.

A. nidulans mut. *albus* Yuill, in publication Jour. of Botany (London).

Colonies of the variety on Czapek's solution agar differ from the species in entire absence of green color. The ascospores have the characters of the species.

Culture obtained by Yuill as a mutant from a normal green strain of *A. nidulans* under investigation in his laboratory. Our record number is *5616.2;* the normal and parent strain is *5616.1.*

A. nidulans var. **latus** var. nov.

Colonies on Czapek's solution agar differing from the species in colony development characterized by a felt of predominantly sterile mycelium (FIG. 2*B*); few conidial heads; fairly abundant perithecia developed in the mycelial felt and each surrounded by a thick covering of hülle cells (FIG. 3*C*), very slowly ripening and

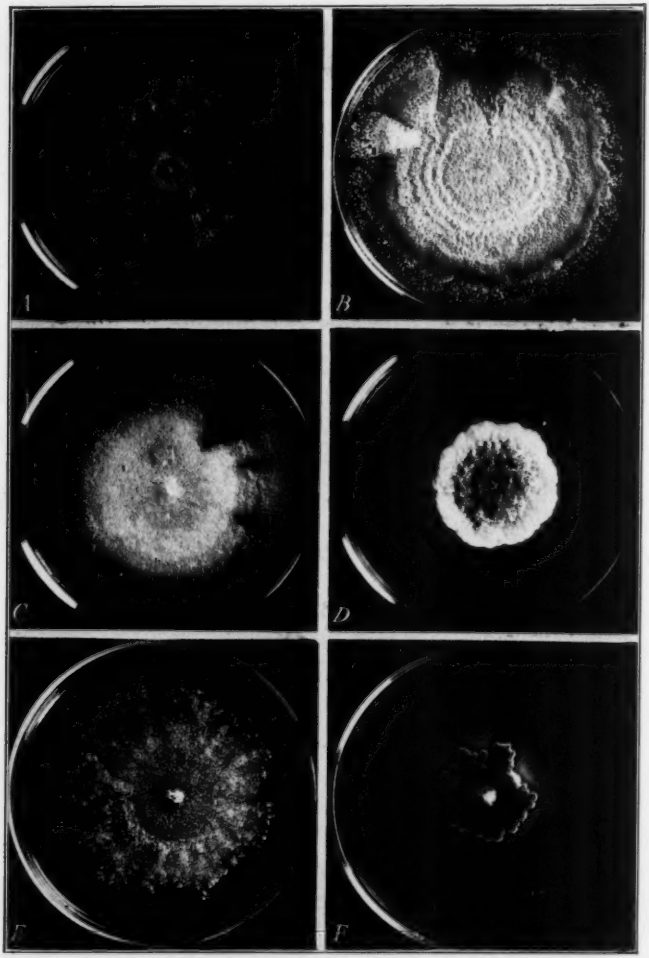


FIG. 2. Comparative growth of different species of the *Aspergillus nidulans* group upon Czapek's solution agar; 3 weeks old. ×½. *A, A. nidulans,* predominantly conidial with scattered perithecia throughout; *B, A. nidulans* var. *latus,* predominantly perithecial with conidial heads largely confined to a marginal zone; *C, A. quadrilineatus,* predominantly perithecial but with abundant conidial heads in marginal zone and in localized sectors; *D, A. rugulosus* almost wholly perithecial, the perithecia being piled in the central area; *E, A. variecolor,* predominantly perithecial with large, pseudostalked perithecia at the colony center and smaller unstalked ones in outlying areas; *F, A. unguis,* wholly conidial with no perithecia present.

containing few and scattered asci in abundant sterile mycelium. Ascospore bodies smooth walled, purple-red, 3.8–4.5 by 3.5–4 μ, with crests 1.5 to 1.8 μ in width.

Type culture No. *110* received from the Centraalbureau in 1909 and remaining constant in culture since that time. Its antecedent history is not known.

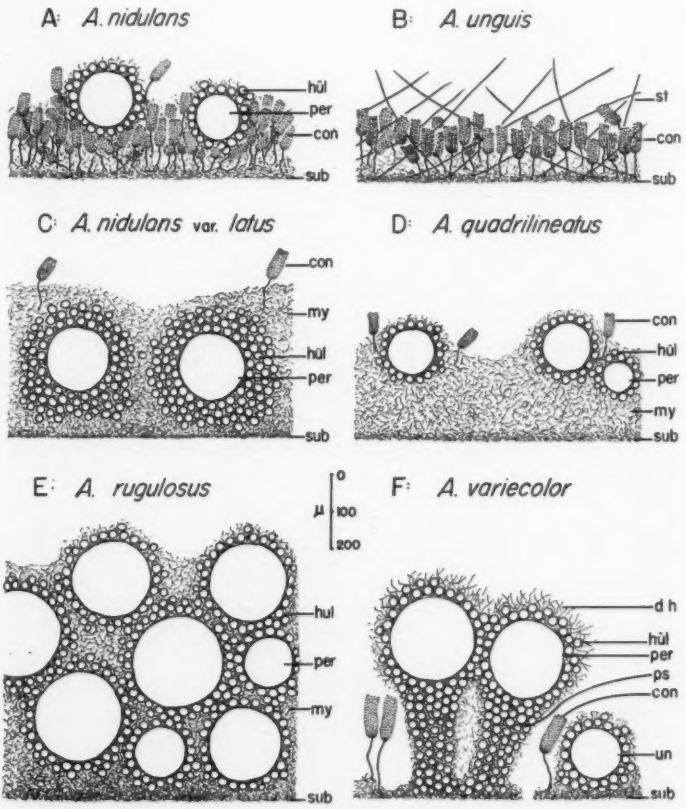


FIG. 3. Diagrammatic representations of cross sections of colonies of different species of the *Aspergillus nidulans* group showing the relative abundance of conidial heads and perithecia and the manner in which these structures are borne: con., conidial heads; d.h., mantle of divergent hyphae; hül., hülle cells; my., mycelial felt; per., perithecia; ps., pseudostalk of hülle cells and sterile hyphae; st., long, thick walled, sterile hyphae; sub., substratum; and un., unstalked perithecium. Scale approximate.

Aspergillus quadrilineatus Thom & Raper, sp. nov.

Coloniis in agaro Czapeki diffusis, planis vel rugosulis, leniter floccosulis, centro purpureo-griseis, et margine interdum areis olivaceis conidicis; reverso purpureo-rubro; capitulis breve columnaribus, fere 60–70 × 30–35 μ, interdum majoribus vel minoribus; stipitibus sinuosis glabro-tunicatis, brunneolis, 50–75 μ longis, 3.5–4.5 μ latis, ad areas vesiculosas hemisphaericas usque 7.5–9 μ dilatis; sterigmatibus primariis 5–6 × 2–3 μ, secundariis 5–7 × 2–2.5 μ; conidiis globosis, pallide flavo-viridibus, rugulosis, 3–4 μ diam.; peritheciis e cellulis "hülle" involutis, pallide brunneolis, sphaericis, in mycelio immersis, circa 125–150 μ diam. strato cellularum "hülle" incluso, pariete stratum cellulae unicae crasso, mox maturantibus; ascis in axe longo 10 μ diam., maturis dissolventibus et ascosporas liberantibus; ascosporis purpureo-rubris, lenticularibus, sine cristis 4–4.8 × 3.4–3.8 μ, cristis duobus plicatis circa 0.5 μ latis et duobus secundariis parallelibus angustioribus interdum indistinctis ornatis.

In culturis ex solo, New Jersey, Texas, Colorado, Louisiana, Maryland.

Colonies on Czapek's solution agar spreading, plane or slightly wrinkled, with tendency toward floccosity, central area gray with a definite purplish tinge, and olive-green conidial areas toward the margin, occasional as sectors (FIG. 2*C*); perithecia developing separately but abundantly throughout the colony; reverse purplish red; heads short columnar, green, mostly 60 to 70 by 30 to 35 μ, occasionally larger or smaller; stalks sinuate, smooth walled, dull brownish in color, 50 to 75 μ in length by 3.5 to 4.5 μ wide, broadening to 7.5 to 9 μ at the hemispherical vesicular areas; primary sterigmata 5 to 6 by 2 to 3 μ, secondary sterigmata 5 to 7 by 2 to 2.5 μ; conidia globose, pale yellow-green, rugulose, 3 to 4 μ in diameter; perithecia enveloped by hülle cells, light brownish in color, spherical, partially embedded in the mycelial felt (FIG. 3*D*), about 125 to 150 μ in diameter including the enveloping hülle-cell layer, with perithecial wall 1-cell layer in thickness, ripening quickly and with ripe asci breaking down to leave the ascospores free; ascospores purple-red, lenticular, with smooth wall, with spore body 4 to 4.8 μ by 3.4 to 3.8 μ, and with two plaited equatorial crests about 0.5 μ in width paralleled by a secondary narrower pair (FIG. 4*B*) which are sometimes indistinct.

Type No. *4138.N8* from New Jersey soil and kept in culture since 1916. Other strains examined include isolations from Texas, Colorado, Louisiana, and Maryland.

Aspergillus rugulosus Thom & Raper, sp. nov.

Coloniis in agaro Czapeki lente et restricteque crescentibus, plicatis vel rugosis, 2–3 mm. altis, saepe denique centro fissis, purpureo-griseis vel

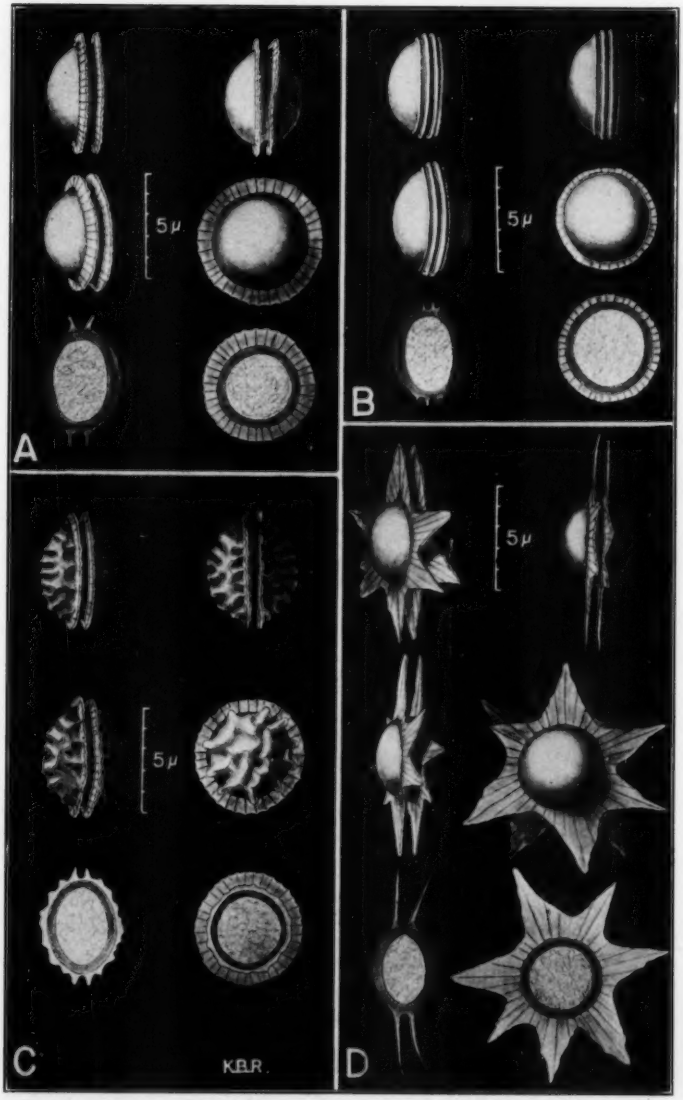


FIG. 4. Ascospores of different species of the *Aspergillus nidulans* group. *A, A. nidulans; B, A. quadrilineatus; C, A. rugulosus; D, A. variecolor.* In each species upper left and right and center left spores represent surface, profile views; center right, surface in face view; lower left, optical section in profile; and lower right, optical section in face view.

vestustis purpureo-brunneis, capitulis viridibus sparsis; reverso purpureo-rubro; capitulis conidioferis breve columnaribus 75–100 × 30–40 μ; stipitibus sinuosis, glabro-tunicatis, pallide brunneis, gracilibus, usque 5 μ latis, in hemisphaerios vesiculosos 8–10 μ diam. dilatis; sterigmatibus primariis 7–8 × 3–3.5 μ, secundariis 6–7 × 2.5–3 μ; conidiis globosis, viridibus, rugulosis, 3–4 μ diam.; peritheciis copiosis, saepe in stratis duobus vel tribus in mycelio immersis, quoque e hyphis et cellulis "hülle" atrobrunneis cincto, globosis, 225–350 μ tegumento mycelico incluso, pariebus atro-rubro-purpureis, stratum cellulae unicae crassis; ascis in axe longo 9–11 μ diam., mox maturantibus, dissolventibus et ascosporas liberantibus; ascosporis purpureo-rubris, sine cristis 4–4.4 × 3.6–3.8 μ, tunicis conspicue rugosis, cristis duobus plicatis aequatorialibus peripherice sinuatis et integris 0.5–0.6 μ latis ornatis.

In culturis ex solo, New Jersey, Texas, Nebraska.

Colonies on Czapek's solution agar slowly and restrictedly growing (FIG. 2*D*), buckled or wrinkled in a mass 2–3 mm. deep, enveloping abundant perithecia at different depths, often eventually splitting in the central area, purple-gray to purple-brown in age, with green heads sparsely produced and hence not generally evident, occasionally seen as small groups and marginal extensions into drying media; reverse in shades of deep purple-red; conidial heads short columnar, 75 to 100 by 30 to 40 μ; stalks sinuous, smooth walled, pale brownish in color, 50 to 80 μ long, slender, varying up to 5 μ in width, then enlarging to vesicular hemispheres 8 to 10 μ in diameter; primary sterigmata 7 to 8 by 3 to 3.5 μ, secondary sterigmata 6 to 7 by 2.5 to 3 μ; conidia globose, green, rugulose, 3 to 4 μ.

Perithecia very abundant, often imbedded in the mycelium as 2 or 3 layers and each surrounded by hyphae and dark brown hülle cells (FIG. 3*E*), globose, 225 to 350 μ in diameter including mycelial coverings, with dark reddish purple walls of one cell thickness, quickly ripening and breaking down to leave ascospores free; asci 10 to 11 μ in long axis; ascospores purple-red, lenticular, walls conspicuously rugulose (FIG. 4*C*), with spore bodies 4 to 4.4 by 3.6 to 3.8 μ, and with 2 plaited equatorial crests with sinuate and entire margins about 0.5 to 0.6 μ in width.

Cultures studied include Type *4138.T11* from New Jersey soil, as discussed in The Aspergilli, p. 138, and also isolates from Washington, D. C., Texas, Nebraska, and California. Believed to be common.

Culturally and microscopically the above strains present similar pictures, with the exception of the strain recently received from Bliss in California (our No. *5667.455*). In contrast to the others, this culture produces abundant conidial heads and relatively fewer

perithecia. The ascospores and conidial structures, however, duplicate those of the typical strains; hence we do not at present feel warranted in designating this as a variety, or otherwise separating it from the species *A. rugulosus*.

A. VARIECOLOR (Berk. & Br.) Thom & Raper.

Emericella variecolor Berk. & Br. in Berkeley, Introd. Crypt. Bot. p. 340–341; *fig. 76.* 1857. See Patouillard, Bull. Soc. Myc. Fr. **7**: 43–49. *pl. 4. fig. 6–12.* 1891.

Inzengaea erythrospora Borzi, Jahrb. Wiss. Bot. (Pringsheim) **16**: 450–463. *pl. 19, 20.* (1884) 1885.

Emericella medias Chowdhury & Mathur, Ann. Myc. **36**: 61–63. 1938.

Aspergillus stellatus Curzi, Rend. Accad. Naz. Lincei **19**: 424–428. *fig. 1.* 1934.

Colonies in Czapek's solution agar with vegetative mycelium largely submerged, sparse, spreading slowly in the agar (FIG. 2*E*), producing green heads freely in the center of the colony, sparsely throughout, large gray perithecia produced in clusters in center and at the margin, with smaller perithecia scattered through the intervening thinner areas of the colony (FIG. 5*A*); reverse color in shades of purple-red. Conidial heads green, columnar (FIG. 5*D*), relatively long, mostly 100–200, occasionally up to 300 μ by 30–40 μ; stalks arising directly from submerged hyphae, straight, with smooth walls, cinnamon-brown in color, mostly 140 to 200 μ long by 3 to 5 μ in diameter, broadening gradually toward vesicular hemispheres about 8 to 10 μ in diameter; primary sterigmata 7 to 8 by 3 to 4 μ, secondary sterigmata 8 to 9 by 2.5 to 3 μ; conidia globose, rugulose, 3 to 3.5 μ; perithecia when clustered (FIG. 5*Aa*) 300 to 400 μ in diameter surrounded by a felt of hyphae and hülle cells and supported by masses of hyphae and hülle cells forming false stalks (FIG. 3*F*), giving the structures a pyriform appearance (FIG. 5*B*); scattered perithecia much smaller (FIG. 5*C*) and with envelope of supporting cells often much reduced in mass; hülle cells abundant and essentially like those of the species *A. nidulans*.

Perithecial wall when stripped of enveloping cells purple-red, brittle, composed of a single layer of cells; asci quickly ripening and breaking down to leave the cavity filled with ascospores; ascospores purple-red, with spore bodies lenticular and 3.6 to 4 by 2.8 to 3 μ, with two prominent equatorial crests, up to 3.5 μ in width, plaited and cut to give a stellate appearance to the ascospores (FIG. 4*D*).

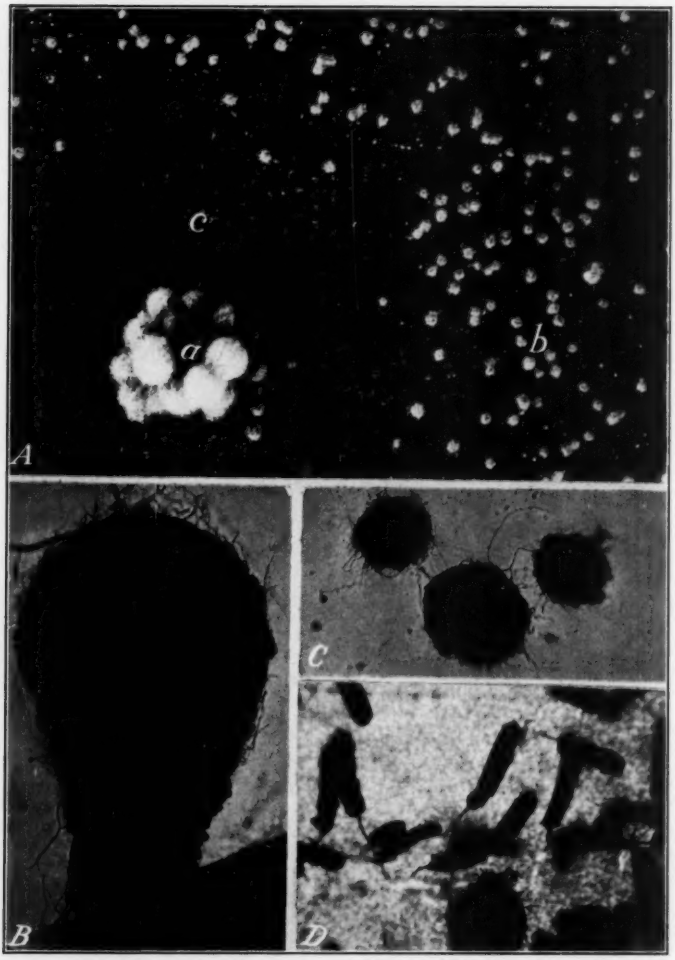


FIG. 5. *Aspergillus variecolor*. *A*, central area of colony; *a*, cluster of large pseudostalked perithecia; *b*, scattered, smaller, unstalked perithecia (see also figure 3*F*); *c*, scattered conidial heads, × 6; *B*, enlarged view of large, pseudostalked perithecium, × 65; *C*, enlarged view of small, unstalked perithecia, × 65; *D*, enlarged view of conidial heads, × 65.

The above description is based primarily upon a culture received from Prof. Verona in Italy and carried in our collection as No. *5602.3*.

Bliss has recently forwarded a culture (our No. *5667.498*) isolated from date fruits in California which differs from the above in the following particulars: (1) Conidial heads are produced abundantly, (2) the mycelium is not predominantly submerged, and (3) the colonies in reverse are deep purple. However, the ascospores of the two strains are strikingly similar in size and pattern, the perithecia of each appear pyriform in shape, and the conidial structures of the two are essentially alike. Consequently we do not feel justified in designating the California strain as a variety, while on the other hand we hesitate to alter the cultural description of *A. variecolor* to include a strain which we have observed in culture for only a few weeks.

Since the type of ascospore described here had already been assigned to *Emericella* and *Inzengaea,* consideration of the literature of these genera is necessary.

Emericella variecolor, genus and species new, was described by Berkeley and Broome in 1857 as doubtfully a Gasteromycete or possibly a lichen. The perithecium with a mass of stellate spores was considered as Gastromycetous in character while what we now recognize as the " hülle " cells of Eidam (figured) suggested to him the possibility of an algal associate. Berkeley's material was also examined by Montagne and part of it deposited in the Museum d'Histoire Naturelle de Paris. This was reexamined by Patouillard in 1891 and its ascomycetous nature determined. No conidial apparatus was found by either Berkeley or Patouillard.

Inzengaea erythrospora as the type species of a new ascomycetous genus was figured and described by Borzi in 1885, showing stellate red ascospores, and the hülle cells of Eidam. Borzi's figure showed a coremium-like conidial apparatus which was designated *Coremium Borzianum* by Saccardo. Ed. Fisher in 1893 transferred the species to *Emericella* of Berkeley and placed the genus next to *Aspergillus* in the *" Pflanzenfamilien."* Saccardo (in Syll. **9**: 610) on the other hand accepted *Inzengaea* and dropped *Emericella* because of the errors in description and placement by Berkeley. Borzi figured the spores of *A. variecolor* (*Inzengaea*

erythrospora) correctly but obviously misinterpreted the germination of the ascospores since he showed them splitting as if turned 90°, bringing the crest perpendicular to the center of the valve instead of attached to its edges.

There the taxonomic situation stood until Vuillemin in 1927 concluded that the ascosporic apparatus, the stellate red ascospores and the cells of Eidam, as clearly shown in their figures and material, showed the identity of *Emericella* and *A. nidulans*. He therefore transferred *A. nidulans* to *Emericella* as the oldest established genus and apparently did not even consider *Inzengaea*.

Ciferri has recently completed a study of *Emericella variecolor* embracing cultural investigations together with a review of the literature of the genus. He did not recognize the close relationship of this fungus to *Aspergillus nidulans*, and was apparently unmindful of the likeness of their conidial structures and the essential similarity of their perithecia and ascospores.

In 1934 Curzi described as *Aspergillus stellatus* a fungus characterized by hülle cells and red, stellate ascospores. However, he apparently did not know of either Berkeley's or Borzi's earlier designation of a similar fungus. It is unfortunate that his exceedingly descriptive binomial must be reduced to synonymy.

Fortunately for this discussion, cultures No. *5602.3* and *5667.498* presented both the stellate spores and apparently stalked perithecia figured by Berkeley, Patouillard and Borzi. (Compare figures *3F* and *5B* with Berkeley's figure *76a*, Patouillard's figures 7 and 8, plate 4, and Borzi's figure 10, plate 19.) This made possible a restudy of the whole morphologic situation from fresh material. The perithecial body itself was found not to be stalked but to rest upon a sterile mass of hülle cells and mycelium giving the superficial appearance noted by earlier observers.

The coremium of Borzi remains unaccounted for. Obviously in Borzi's discussion the material was rotten olives and very old. No cultures were made. The conidia producing apparatus figured differs essentially in type from the conidial apparatus of the Aspergillaceae with which Fischer correctly placed *Emericella* because of its perithecia and ascospores. We are convinced that the coremia belonged to some other fungus.

It is not possible to separate the perithecium of this fungus from

that of the other species in the *A. nidulans* group nor are there characters to take this type of perithecium out of a genus with the yellow perithecium of the great *A. glaucus* series of species which are widely known. Consistent with the policy of keeping the Aspergilli in one group, both *Emericella* and *Inzengaea* are dropped for purposes of this discussion.

ASPERGILLUS UNGUIS (Emile-Weil & Gaudin) Emend. Thom & Raper.

Sterigmatocystis unguis Emille-Weil & Gaudin, Arch. Med. Expt. Anal. Path. Paris **28**: 463–465. *fig. 4.* 1919.

Colonies on Czapek's solution agar restrictedly growing, plane, spreading at the margin as irregular lobes (FIG. 2*F*), yellowish-

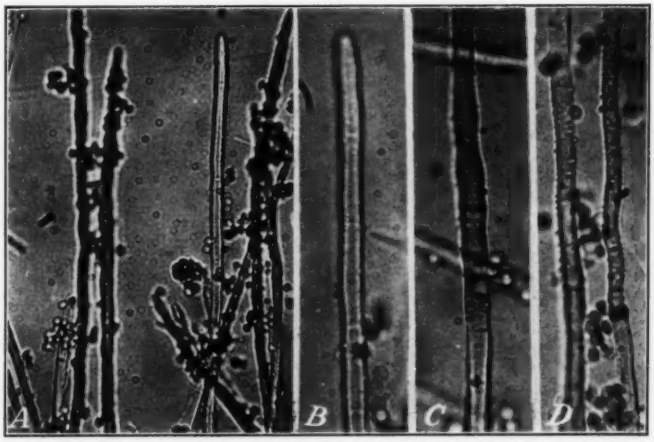


FIG. 6. Sterile spicule hyphae of *Aspergillus unguis*. *A*, cluster of sterile hyphae, × 370; *B*, apex of sterile hypha, × 740; *C* and *D*, mid portions of sterile hyphae showing thick roughened walls, × 740.

green, green to dark green becoming brown in age; without perithecia or hülle cells. Mycelial preparations show striking sterile, thick walled hyphae with walls in brown shades, irregularly roughened (FIG. 6), tapering to a blunt point, arising sometimes from foot-cells suggesting the origin of stalks, sometimes apparently from mycelial cells, often up to 1000 μ or more in length, slanting

upward but usually rising only slightly above the conidial area (FIG. 3*B*).

Conidial heads columnar, 75 to 150 by 40 to 50 μ; stalks smooth walled, dull brown in color, mostly 45 to 65 μ in length by 3 to 5 μ in diameter, enlarging to vesicular hemispheres 9 to 12 μ in diameter; primary sterigmata 5 to 6 by 2.5 to 3 μ, secondary sterigmata 5 to 6 by 2 to 2.5 μ; conidia globose, rugulose, dull green, 2.5 to 3.5 μ in diam.

Cultures obtained frequently from medical laboratories apparently as more or less active pathogens but occasionally isolated from soil and decaying organic matter. The question whether the non-ascosporic members of the group have merely dropped the ascogenous phase or constitute a separate species was answered when more complete examination showed the sterile or spicule hyphae to be regularly produced in the non-ascosporic, but never found in ascosporic series.

SUMMARY

The *Aspergillus nidulans* group is divided into five species primarily upon the character of the ascospores produced. Differences in colony characters are also correlated with differences in ascospore pattern and further substantiate the validity of the present separation.

The following species are recognized or described as new: (1) *Aspergillus nidulans,* characterized by a smooth walled ascospore bearing two parallel, equatorial crests of 0.5 to 1.0 μ width; (2) *Aspergillus quadrilineatus,* characterized by a smooth walled ascospore typically bearing four equatorial crests; (3) *Aspergillus rugulosus,* characterized by a rough walled ascospore; (4) *Aspergillus variecolor,* characterized by a smooth walled ascospore bearing two equatorial crests 3.0 to 3.5 μ in width and strongly dissected, giving the spore a stellate appearance when seen in face view; and (5) *Aspergillus unguis,* lacking perithecia and ascospores and characterized by the presence of long, roughened, sterile, spicule hyphae not found in other species.

A new variety, *Aspergillus nidulans* var. *latus,* is described, and differs from the species in the much wider crests of the ascospore and in colony character as well. A white mutant of *Aspergillus*

nidulans isolated and described by Yuill as *A. nidulans* mut. *albus* is accepted.

The writers are indebted to Edith K. Cash for preparing the Latin diagnoses.

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TWO NEW SPECIES OF RUST

W. H. Long & L. N. Goodding

(WITH 2 FIGURES)

This paper describes two new species of rusts, namely, *Ravenelia Dysocarpae* on *Mimosa dysocarpa* and *Gymnosporangium Vauquelinae* with the aecial stage on *Vauquelinia californica* and telia on *Juniperus monosperma.*

Ravenelia Dysocarpae Long & Goodding, sp. nov.

0 & II.—Pycniis et urediis ignotis; urediosporis in teliis, globosis, 15.5–21.7 microns, pallide flavida, verruculosis, poris germ. obscuris, sparsis.

III.—Teliis amphigenis plerumque epiphyllis, subcuticularibus, atro-brunneis; capitulis teliosporarum levibus, 56–80 microns diam., paraphysibus 7–10 × 43–53 microns, cystidiis hyalino; pedicello hyalino.

0.—Pycnia unknown.

II.—Uredinia not seen; urediospores in the telia, globoid, 15.5–21.7, average size for 20 spores 18.44 microns, usual size 18.6 microns, walls pale fulvous, 1½–2 microns thick, uniform, closely verrucose, germ pores many, scattered.

III.—Telia amphigenous, mainly epiphyllous, scattered, irregular in shape, 1 mm. or less across, subcuticular, soon naked, blackish-brown, shining, ruptured cuticle inconspicuous; paraphyses few, intermixed very sparingly with the teliospores, spoon-shaped to clavate, 7–10 by 43–55 microns, average for ten 9.6 by 49.6, usual size 10 × 50 microns, heads thickened at apex 4–5 microns, becoming thin on lower ⅓ of head, chestnut-brown, stipe hyaline, solid, curved; teliospore heads chestnut-brown, 5–8 cells across, 55.8–80.6 microns in diameter, average for 20 heads 67.5 microns, usual size 65 microns, smooth, cysts hyaline, globoid to oblong, beneath entire head, very slowly swelling and bursting in water, not coherent, sometimes breaking away from head; pedicel hyaline, short, deciduous.

On Mimosaceae-type collected on *Mimosa dysocarpa* Benth. 5 miles south of Arivaca, Arizona, 10–1–36 by *Leslie N. Goodding* (Type No. *7714* Long) also collected on same host in Sycamore

Canyon about 5 miles from Ruby, Arizona, 10–3–36 by *Leslie N. Goodding* (No. *7716* Long).

Gymnosporangium Vauqueliniae Long & Goodding, sp. nov.

0.—Pycniis epiphyllis, minutis, 200–270 microns latis, 100–150 microns altis.

I.—Aeciis hypophyllis, petiolicolis et floricolis, matricem deformantibus et "Hexenbesen" vel "witches-brooms" efformantibus, cylindraceis, 5–8 mm. altis 0.4–0.5 mm. latis, flavo-brunneis, ad apicem dehiscentibus; aeciosporis, globosis vel ellipsoideis, minute verruculosis, 18.6–24.8 × 21.7–34 microns, episporio 3–4 microns, crasso.

III.—Teliis ramicolis, ad ramos minores interfolia evolutis, sparsis, plerumque solitariis, hemisphaericis vel globosis, 0.5–1.5 mm. diam., brunneis; teliosporis, media 1-septatis et non vel vix constrictis, dilute brunneis, ellipsoideis, 15.4–21 × 52.2–64.4 microns, episporio 1.2–3 microns, crasso, quaque cellula poris germantionis 2 prope septum positis; pedicello hyalino, cylindraceo, 50–75 microns longo.

0.—Pycnia epiphyllous, numerous, scattered over entire upper surface of the leaf, punctiform, honey-yellow becoming dark brown with age, globoid, 200–270 microns in diameter by 100–150 microns high.

I.—Aecia numerous, gregarious, causing hypertrophy of leaves, peduncles and pedicels of the inflorescence forming globoid "witches-brooms" (FIG. 1) 3–10 cm. in diameter, cylindrical, 0.4–0.5 mm. in diameter by 5–8 mm. high (FIG. 2); peridium white (hyaline), rather tough, rupturing at the apex, not lacerate on sides, remaining tubular, lower portion containing undischarged spores, lead color; peridial cells usually seen in face view, hyaline, narrowly lanceolate to lozenge-shaped, remaining straight when wet, 25–31 × 62–93 microns, usual size 28 × 85 microns, oblong in side view, 22–31 microns thick, outer wall smooth about 3 microns thick, inner and side walls closely spinulose; aeciospores globoid to broadly elliptical, 18.6–24.8 by 21.7–34.1 microns, usual size 18.6 × 24.8 microns, walls fulvous, 3–4 microns thick, germ pores 7–10, scattered, finely verrucose.

On Rosaceae. Type for pycnia and aecia on *Vauquelinia californica* Sarg. (an evergreen) on Superstition Mountain (el. 4,000 ft.) about 25 miles east of Mesa, Arizona, Nov. 1, 1935, and May 5, 1939, by *L. N. Goodding* (Type No. *7720* Long) and (No. *8370* Long).

FIG. 1. Upper, shows inflorescence of *Vauquelinia californica* changed into a witches-broom by the aecia of *Gymnosporangium Vauqueliniae*, × 1; lower, shows the aecial "horns" on a pedicel of the inflorescence, × 2½. Note the slenderness of the horns.

II.—Uredia wanting.

III.—Telia caulicolous, forming a slight witching of the twigs, arising between the scale-like leaves on the green twigs, these showing a distinct yellowing with age, scattered, or in clusters of 2 or more individuals, hemispheric to globoid, 0.5 to 1.5 mm. in size, reddish brown, easily falling away from twigs when desiccated; teliospores 2-celled, ellipsoid, 15.4–21 by 52.2–64.4 microns, usual size 18 × 56 microns, not or very slightly constricted, usually narrowed above and below, lower cell often more narrowed than the upper one; walls 1.2–3 microns thick, fulvous to hyaline, the pores 2 to each cell near septum; pedicel hyaline, cylindrical, 3–4 microns thick, occasional pedicel 9–10 microns thick, 50–75 microns long, solid, easily breaking away at base of spore.

On Juniperaceae. Type for telia collected on *Juniperus monosperma* (Engelm.) Sarg. on Superstition Mountain, Arizona, April 4, 1936, and May 5, 1939, by *L. N. Goodding* (Type No. *8361* Long), and (No. *8371* Long), known only from type locality.

This beautiful species of *Gymnosporangium* is unique in several ways. Its aecial stage occurs on an evergreen where it produces "witches-brooms" of the inflorescence, the first case known to the writers. "Witches-brooms" are common on the telial hosts of *Gymnosporangium* but not on the aecial host. The infected leaves are only those attached to the inflorescence and the aecia are mainly hypophyllous.

NEW SPECIES AND TAXONOMIC CHANGES IN THE HYPODERMATACEAE

L. R. Tehon

(WITH 6 FIGURES)

Since the publication in 1935 of my studies of *Lophodermium* (**15**) I have had opportunity to examine numerous specimens belonging to that genus and to related genera. Some of the specimens had been collected recently, and there was among them representative material of undescribed species; others represented recently described species or had been recently mentioned in literature; and still others were *exsiccati,* or other authoritative specimens, which I examined as reference material. From them I have accumulated a miscellany of new species, taxonomic reallocations, and particular notes, which I present below.

Because the morphology and host relations of the hysterothecium have been emphasized, first by von Höhnel (**7**) and later by Nannfeldt (**11**), Darker (**3**), and Tehon (**15**), in the classification of the Hypodermataceae, I have deemed it necessary to follow a set of criteria, based on the characteristics of the hysterothecium, which would determine the disposition of species in families and genera. The criteria I have set up do not constitute a complete system, and they are not wholly consistent; but they have at least the advantage that they exclude from the Hypodermataceae species that could not reside permanently in that family.

For inclusion in the Hypodermataceae, I have required a fungus to exhibit (1) an oval to elongated, covered ascoma containing a discoid hymenium; (2) a marginal separation of the hysterothecial wall into a cover-plate and a base-plate; (3) an elongated, morphologically defined ostiole; and (4) an ostiolar lining of periphyses. With scolecosporic species, those formerly assignable to *Lophodermium,* I have relied upon the level at which the hysterothecium is inserted in the host tissues to determine the generic assignment. But with species having stalked, clavate asci and elongated, one- to

two-celled spores, those assignable to *Hypoderma,* I have not employed the insertion level as a generic criterion.

Specimens representing three of the species I am reporting on failed to meet the requirements for inclusion in the Hypodermataceae. They were all scolecosporic; and, for reasons given in an earlier paper (**14**), I have assigned the species to *Clithris,* the only suitable genus in the Phacidiaceae.

These phacidiaceous specimens all possess ascomata very different in structure (FIGS. 2, 5, 6) from those of *Lophodermium* and *Hypoderma.* Although dehiscence is by means of a lengthwise opening in the roof of the ascoma, sections do not reveal the group of structures which Nannfeldt (**11**) termed the *Mündungsmechanismus:* there are no periphyses; there are no *Quellkörpern*; and there is no *Öffnungsmechanismus*—the " slit-band " of Darker (**3**); instead, the irregularity of the slit, the tapered thinness of the surrounding labia, and the absence of differentiation in structure point to an entirely mechanical method of dehiscence. The walls of the ascomata may be carbonaceous throughout (FIG. 2) or only in the roof and base (FIGS. 5, 6), and they may vary greatly in thickness. The pseudoparenchyma of the ascoma wall is continuous, and sections give no evidence that separate base-plates and cover-plates exist. Between the wall and the hymenium, along the sides of the ascoma, there is an inclosing tissue consisting of hyaline, regularly oblong, palisade-like cells, which may be regarded structurally as the exciple of the stromatically inclosed apothecium, if Nannfeldt's (**11**) contention that the fruiting body is an *Apothecienstroma* is accepted, or as a pressure-exerting mechanical tissue concerned with the opening of the ascoma, if a functional explanation is preferred.

Clithris Camelliae (Teng) comb. nov. (FIG. 6).

Lophodermium Camelliae Teng, Sinensia **4**: 138. 1933.

Apothecia foliicolous, amphigenous, scattered and few to numerous in pale yellow to ashen, often brown margined, circular spots up to 1 cm. in diameter, dull black, short- to long-oval, straight to lunate, 350–700 × 225–310 μ, heavily carbonized in the cover, in a much enlarged median region in the base, and at the margins, elsewhere thin and often more or less translucent; slit nearly as long as the apothecium, with labia and periphyses lacking. Paraph-

yses abundant, filiform, simple, straight or flexuous, exceeding the asci, without an apparent gelatinous case, variously bent and crushed toward the tips and interwoven to form a yellowish epithecium, 75–155 μ long, 1–1.5 μ wide. Asci cylindrical, straight to flexuous, bluntly and symmetrically rounded at the tips, tapered near the base to a short stalk, 82–115 $\times$ 5–7 μ, chiefly 90–105 $\times$ 5–6 μ, 8-spored. Ascospores hyaline, filiform, straight or flexuous, fasciculate in pairs in the ascus, 62–78 $\times$ 1–1.5 μ, without an apparent gelatinous matrix.

Type specimen: S. C. Teng, No. *1904* (No. *77* in the Metropolitan Museum, Academia Sinica, Nanking, China); type locality: Foochow, Funkien province, China; host: *Camellia* sp., on fallen leaves; specimen examined: part of the type, labeled "co-type" by Dr. Teng.

Teng (*l. c.*) has remarked that this fungus is related to *Lophodermellina hysterioides*. Such a conclusion might readily be reached from the gross appearance of the spots and fruiting structures. Sections show, however, that it lacks the characteristic structure of an hypodermataceous form and is assignable, instead, to the Phacidiaceae. No periphyses are present; and the apothecial opening, at first a linear slit of purely mechanical origin, is eventually enlarged by the breaking away of the carbonized cover so as to expose the hymenium freely. Although the apothecia are apparently laid down in the epidermis, they show no differentiation into morphologically separate covers and bases; and radial plates of mycelium are entirely lacking.

Clithris leucothoicola sp. nov. (FIG. 5).

Apothecia foliicolous, amphigenous, scattered in cinereous, unlimited spots of very variable extent, shining black, subrotund to elliptical, straight to lunate, isolated, contiguous, or merged laterally or terminally, 330–790 $\times$ 260–300 μ, subcuticular, heavily carbonized in the cover on each side of the slit, in a somewhat swollen median portion of the base, and at the margins, elsewhere thin and more or less translucent; opening widely, the slit nearly as long as the apothecium, erose margined, mechanically developed, and lacking periphyses. Paraphyses abundant, hyaline to yellowish, filiform, simple, straight or flexuous, without apparent gelatinization, exceeding the asci and variously crushed and bent above to form a dense yellow epithecium up to 15 μ thick, 120–165 μ long, 1–1.5 μ wide. Asci cylindrical, straight to flexuous, bluntly

rounded above, tapering below to a long, slender stipe and inconspicuous foot, 107–157 × 5–6.5 μ, 8-spored. Ascospores hyaline to faintly yellow, filiform, straight, fasciculate in pairs, 60–110 × .75–1 μ, gelatinous matrix inconspicuous.

Apotheciis sparsis, atronitidis, subrotundatis usque ellipticis, subcuticularibus, 330–790 × 260–300 μ, carbonaceis in regione rimae, in regione fortiter afflata in medio basis, et in margine; fissuris latis, longitudinalibus, non periphysibus ornatis aperientibus; paraphysibus filiformibus, simplicibus, ascos excedentibus, epithecium vitellinum, 15 μ densum formantibus, 120–165 × 1–1.5 μ; ascis cylindricis, 107–157 × 5–6.5 μ; ascosporis cylindricis, 60–100 × .75–1 μ, cum matrice gelatinosa inconspicua.

Type specimen: B. H. Davis, May 24, 1931; type locality: Strondsberg, Pennsylvania; host: *Leucothoë Catesbaei* (Walt.) Gray; specimens examined: the type (communicated by R. P. White) and another collected by R. P. White, Princeton, New Jersey, May, 1929.

The specimens cited above were reported by White (**16**) as *Lophodermium*. On species of Leucothoë three fungi with elongated ascomata have been reported, namely, *Hypoderma variegatum* (Berk. & Curt.) Duby, *Clithris Andromedae* (Schw.) Ellis & Ev., and *Lophodermellina hysterioides* (Pers.) von H. Both *H. variegatum* and *C. Andromedae* are described, and the latter is illustrated, by Duby (**5**). Both are described also by Ellis and Everhart (**6**). These descriptions and illustrations indicate clearly, as does also comparison with No. *155* of Ellis' North American Fungi, that the present fungus is essentially different in the size and shape of its asci and ascospores, as well as with respect to other important characters. It is probable that the report of *L. hysterioides* on this host is the result of an erroneous identification.

Clithris Rosae (Teng) comb. nov. (FIG. 2).

Lophodermium Rosae Teng, Sinensia **4**: 138. 1933.

Apothecia scattered but numerous in well defined creamy white areas on stems, dull black, without directional orientation, discrete or sometimes confluent end-to-end, narrowly oval to elongate or linear, with bluntly rounded ends, 650–1800 × 200–400 μ, with thick walls heavily carbonized throughout, cover brittle and tending to break away irregularly, opening by a longitudinal slit nearly as long as the apothecium; periphyses lacking. Paraphyses abundant, hyaline, filiform, simple, straight or flexuous, of uniform

diameter, exceeding the asci and crushed, bent, and intertwined above them to form a dull white to yellowish epithecium 15–25 μ thick, 90–150 $\times$ 1.5–2 μ, apparently without a gelatinous matrix. Asci cylindrical, straight or somewhat flexuous, bluntly and symmetrically rounded at the tips, tapered near the base to a pronounced foot, 85–140 $\times$ 5–7 μ, 8-spored. Ascospores hyaline, filiform, straight, flexuous, or rarely coiled in the ascus, fasciculate in pairs, 35–70 $\times$ 1.5–2 μ, without a gelatinous matrix.

Type specimen: C. I. Shen, No. *390* (No. *76* in the Metropolitan Museum, Academia Sinica, Nanking, China); type locality: Hengshan, Hunan province, China; host: *Rosa* sp., on dead twigs; specimen examined: part of the type, labeled "co-type" by Dr. Teng; illustrations: Teng, Sinensia **4**: 144, *fig. 15*. 1933.

Teng has pointed out (*l. c.*) that this fungus differs from *Lophodermellina hysterioides* (Pers.) von H. in its strictly ramicole habit and in characteristics of the paraphyses, asci, and ascospores. It is also subepidermal in insertion and does not possess the aliform plates characteristic of *L. hysterioides*. Sections show, also, that it is not referable to *Lophodermium*. As has been pointed out by Nannfeldt (**11**) and by Tehon (**15**), the hysterothecia of this genus open in a manner much resembling that of the Sphaeriales, and their elongated ostioles are lined with periphyses. The opening in this Chinese fungus is a purely mechanical split, the edges of which bear no periphyses; no labia are present; and there is no division of its apothecium into base and cover plates.

Bifusella Vaccinii sp. nov.

Bifusella Vaccinii (Carmichael) Tehon, Illinois Biol. Monographs **32** (51): 117. 1935. In part.

Hysterothecia appearing golden-brown, scattered or crowded, often oriented parallel with the stem axis, on dead portions of stems, broadly elliptical with somewhat truncated ends, 450–675 μ long, 325–375 μ wide, subepidermal. Labia of the slit indefinite, somewhat thickened and carbonized in the middle, $\frac{2}{3}$–$\frac{3}{4}$ the length of the hysterothecium. Base a thin plate of loose pseudoparenchyma browned at the cell unions but scarcely distinguishable from the thin hyaline plectenchyma from which the hymenium arises; cover a compact, brown translucent plectenchyma underlaid to varying thicknesses by brown pseudoparenchyma. Paraphyses filamentous, hyaline, straight or flexuous, variously bent or crushed

at the tips which are gelatinously fused into a thin white epithecium, 90–115 μ long, about 1 μ wide. Asci clavate, truncately rounded above, tapered to a long, fine stipe, 85–100 μ long, 15–20 μ wide, 4-spored. Ascospores hyaline, nonseptate, bifusiform, 55–62 μ long, 4–5 μ wide, incased in a conspicuous, hyaline gelatinous matrix, 2.5–3 μ thick.

Hysterotheciis aureis-brunneis, sparsis aut confertis, late ellipticis et utrimque truncatis, subepidermalibus, 450–675 × 325–375 μ; labiis rimae non bene definitis, in medio carbonaceis; basi pseudoparenchymatica; tegmine pseudoparenchymate compacto, brunneo, translucente; paraphysibus filiformibus, hyalinis, epithecium album formantibus, 90–115 × 1 μ; ascis clavatis, supra truncate rotundatis, longis pedicellatis, 85–100 × 15–20 μ, quadrisporis; ascosporis bifusiformibus, hyalinis, continuis, 55–62 × 4–5 μ, cum matrice gelatinosa hyalina, conspicua, 2.5–3 μ densa.

Type specimen: Reliquiae Farlowiana No. *46;* type locality: New Hampshire; host: *Vaccinium pennsylvanicum* Lam.; illustration: Tehon, Ill. Biol. Monog. **32** (51): 118, *fig. 1.* 1935.

Bifusella, according to von Höhnel (**7**), is subcuticular and stromatic. This fungus possesses neither of these characters. But Darker (**3**) has pointed out that it is the only hypodermataceous genus to which bifusiform-spored fungi can be assigned. Boughey (**1**) has determined, by examining the type specimens in the Kew Herbarium, that *Hysterium Vaccinii* Carm. is a *Gloniopsis* and that *Hysterium cladophyllum* Lév., as represented by Mougeot and Nestler's Stirp. Crypt. No. *1243,* has filiform spores. This, he states correctly, leaves *Bifusella Vaccinii* (Carm.) Teh., an untenable binomial for either *Hysterium Vaccinii* or *H. cladophyllum.* It is, however, the only tenable name for the American bifusiform-spored material on *Vaccinium* and is here formally proposed in that sense.

Hypoderma Apocyni sp. nov. (FIG. 3).

Hysterothecia shining black, discrete, oriented parallel to the stem axis in yellow to cinereous, unlimited spots of small to large extent, narrowly elliptical to fusoid in outline, with sharply rounded to acute ends, 1–2 mm. (1100–1975 μ) × 270–420 μ, subcuticular. Labia indistinct and merging with the cover, carbonized along the length of the ostiole, narrow at the ends, broader in the middle, conforming in outline to the hysterothecial shape, up to 90 μ wide, and 40 μ thick, lined inwardly by a dense mass of bright yellow, clavately expanded, gelatinously agglutinated, persistent periphyses

7–15 × 3–4 μ. Cover well arched, carbonized only in the labia, elsewhere brown and more or less translucent, consisting of an outer plate of radiately disposed aliform hyphae thickened toward the middle by the apposition, below, of 1 to several layers of brown pseudoparenchyma, separate from the base at the margins. Basal layer a brown, translucent, concave plate of radially disposed aliform hyphae, occasionally thickened by the apposition, above, of small patches of brown pseudoparenchyma; this overlaid by a plectenchyma 8–15 μ thick of fine, closely interwoven, hyaline hyphae from which the hymenium arises. Paraphyses abundant, filiform, flexuous, much exceeding the asci, irregularly uncinate, coiled, or spiraled toward the unexpanded tips, without apparent gelatinization and not forming a compact epithecium, 0.75–1 μ wide. Asci narrowly clavate and long stalked, bluntly rounded above, 80–100 × 8–12 μ, 8-spored. Ascospores elongated, straight or curved, obtuse distally, acute below, 1-septate, not constricted, fasciculate and in pairs, 21–28 × 2.5–3.5 μ, without a gelatinous matrix.

Hysterotheciis atronitidis, discretis, anguste ellipticis usque fusoideis, in apicibus acute rotundatis, subcuticularibus, 1–2 mm. × 270–420 μ; labiis ostioli carbonaceis, usque 90 μ latis et 40 μ densis, periphysibus flavis clavatis, 7–15 × 3–4 μ ornatis; tegmine et basi radiantibus et ex hyphis aliformibus compositis; paraphysibus filiformibus, ascos multo excedentibus sed epithecium compactum non formantibus; ascis clavatis, longis pedicellatis, 80–100 × 8–12 μ; ascosporis rectis vel curvatis, supra obtusis, basim acutis, 1-septatis, 21–28 × 2.5–3.5 μ.

Type specimen: J. R. Hansbrough, No. *1766*, August 27, 1935; type locality: Pine Plains, New York; host: *Apocynum medium* Greene, on dead stems.

No species of *Hypoderma* appears to have been reported previously on any member of the Apocynaceae in America. *H. commune* (Fries) Duby as commonly reported on dead stems of various herbs is undoubtedly a "catch-all" species into which many distinct forms have been thrown as a result of the imperfect definitions promulgated by Duby (**5**) and Rehm (**13**); but considering even the wide and inclusive range of forms these authors have suggested for it, this fungus is distinct from it in size of ascus and ascospore as well as hysterothecial characters.

Hypoderma Caryae sp. nov. (FIG. 1).

Hysterothecia shining black, scattered, discrete, oriented parallel with the petiole axis in ashen to white, unlimited spots of variable,

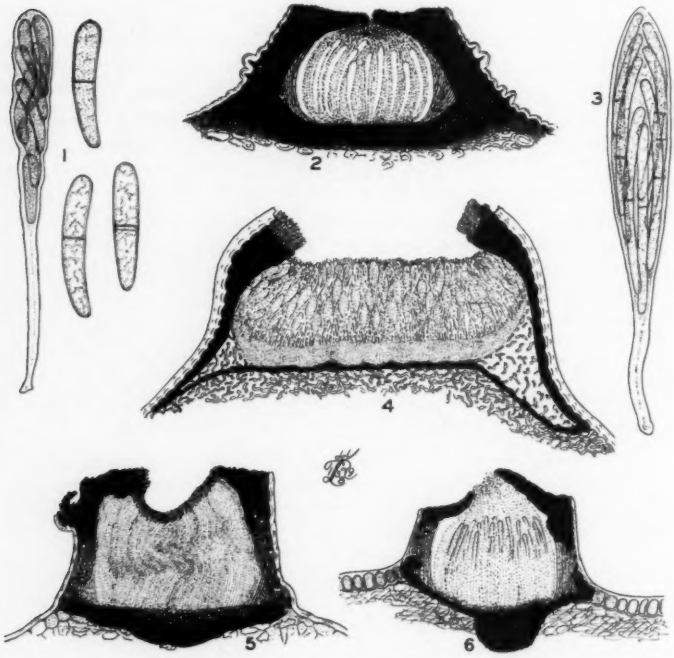
often large, extent, narrowly elliptical with bluntly rounded ends, 800–1500 × 270–400 μ, subcuticular. Labia indistinct, merging gradually into the hysterothecial cover, up to 45 μ thick at the ostiole, carbonized and opaque to a width of 65 μ, never extroverted, lined with a loose mass of hyaline to cream-colored, clavately expanded, gelatinously agglutinated, persistent periphyses 5–10 × 2–2.5 μ. Cover rather flat, carbonized in the labia, elsewhere brown and more or less translucent, consisting of an outer plate of chitinized, radiately disposed, aliform mycelium and 2 or more layers of underlying brown pseudoparenchyma. Basal layer a concave plate 1 cell thick of brown, translucent, radiately disposed aliform hyphae overlaid to a depth of 8–10 μ by a hyaline plectenchyma of very fine hyphae from which the hymenium arises; base and cover closely applied to each other at the margins to a width of 60–80 μ. Paraphyses abundant, hyaline, flexuous, simple, exceeding the asci and often somewhat expanded or flattened above them into an imperfect, shining white epithecium, 75–120 μ long, .75–1.25 μ wide. Asci clavate and long stalked, rounded above, 74–100 μ long, 8–11.5 μ wide, 8-spored. Ascospores hyaline, elongated, fusiform, non-septate in the ascus, 1-septate after emission. curved, bluntly rounded distally, tapered and subacute at the base, more or less fasciculate and in pairs, 18–26 × 2.5–3.6 μ, without an apparent gelatinous matrix.

Hysterotheciis sparsis, atronitidis, discretis, anguste ellipticis et utrimque rotundatis, subcuticularibus, 800–1500 × 270–400 μ; labiis ostioli carbonaceis, 65 μ latis, 45 μ densis, periphysibus hyalinis usque cremeis, clavatis, 5–10 × 2–2.5 μ ornatis; tegminibus planioribus, ipsis et basibus radiantibus, ex hyphis aliformibus compositis, in margine per 60–80 μ disculum formantibus; paraphysibus hyalinis, flexuosis, supra ascos epithecium lucidum album formantibus, 75–120 × .75–1.25 μ; ascis clavatis, longis pedicellatis, 74–100 × 8–11.5 μ; ascosporis hyalinis, elongatis, fusiformibus, curvis, basim subacutis, continuis in ascis, postea 1-septatis, 18–26 × 2.5–3.6 μ.

Type specimen: H. G. Eno, November 7, 1935 (communicated by J. R. Hansbrough, No. *1772*); type locality: Harvard Forest, Hamilton, Massachusetts; host: *Carya glabra* (Mill.) Spach., on fallen petioles.

The subcuticular insertion ascribed to the hysterothecia of this species is determinable with difficulty. The hysterothecial cover appears directly applied to the cuticle; but the internal mycelium brings about complete dissolution of the epidermal cells and underlying tissues, except strands of sclerenchyma; and, except occasionally at the hysterothecial margins, no cell fragments remain by which the insertion can be determined with certainty. Never-

theless, the close adherence of the cover to the cuticle, the clearcut aliform structure of both the cover and base, and the close application of the margins of the cover and base to each other indicate clearly a subcuticular development.



FIGS. 1–6. Morphology in *Hypoderma* and *Clithris*.

The fact that the ascospores are non-septate until after extrusion from the ascus might seem to justify placing the fungus in *Hypodermella;* but on the basis of the type species, *H. Laricis* v. Tubeuf, and of other pinicolous species clearly congeneric, Darker (3) has more clearly defined the genus as including only distinctly clavate spores. He has, however, segregated in his genus *Elytroderma* a pinicolous species, *Hypoderma deformans* Weir, which this hickory fungus resembles in spore shape, in part because its ascospores become bicellular in maturity; but the

intended taxonomic distinction between it and *Hypoderma Rubi* (Pers. *ex* Fries) De Not., type species of *Hypoderma,* is not clear, since the ascospores of the latter also become bicellular.

HYPODERMA EQUISETI Ellis & Ev.

What presumably is to be regarded as part of the type specimen of this species, Ellis and Everhart's Fungi Columbiani No. *1335,* on dead stems of *Equisetum hyemale* L. from Rooks County, Kansas, proves in the copy available to me to be sterile and in such poor condition as to be incapable of any kind of identification. Sections reveal disorganized stromatic fungus tissue beneath the epidermal cells but give no key to structure.

HYPODERMA ERICAE von Tubeuf.

Two specimens have been available to me, both in Otto Jaap's Fungi selecti exsiccati. Number *707,* on *Erica verticillata* Forsk., from Dalmatia, bears no asci. Sections reveal a black stromatic structure, sphaerical in cross section, without differentiation into cover and base, that occupies most of the mesophyl, extends into the lumina of the outer (upper) epidermal cells and contains nothing but a small sphaerical body, possibly an internal parasite. Some of the latter appear, in the sections, to bear immature asci; but no mature asci were found in crushed preparations. None of the customary features of an hysterothecium can be discerned.

Number *558,* on *Erica carnea* L., from Südtirol, is also sterile and exhibits the same suggestive evidence of internal parasitization.

Hypoderma Eupatorii sp. nov.

Hysterothecia abundant, shining-black, spindle-shaped, acute at both ends, straight or somewhat curved, oriented parallel to the stem axis in very extensive, unlimited stramineous areas, discrete or rarely contiguous or fused laterally or terminally, 1.2 to 2.3 mm. long, 415–520 μ wide, subcuticular. Labia prominent, arched, spreading uniformly, up to 65 μ thick, heavily carbonized and often breaking away, uniformly 65–80 μ wide, nearly as long as the hysterothecium, bordered inwardly by a mass of gelatinously agglutinated, bright greenish, clavately expanded periphyses 12–15 $\times$ 1.5–3.5 μ, that are persistent and rufescent in age. Basal layer a thin plate of irregular, radiately disposed prosenchyma, dilute

brown and translucent, definitely limited marginally by a series of aliform terminal cells, overlaid to a depth of 8–17 μ by a closely interwoven plectenchyma of fine hyaline hyphae, from which the hymenium arises. Cover a dark, usually carbonized but sometimes translucent brown, well-arched plate of pseudoparenchyma extending marginally somewhat beyond the base and with aliform terminal cells intermixed with straggling fringe-like cylindrical hyphae of varying lengths at the margin. Paraphyses hyaline, filiform, straight or curved, equalling to much exceeding the asci, variously crumpled at the tips but not gelatinously encased or agglutinated, up to 124 μ long, 1–1.5 μ wide. Asci clavate, tapered below to a long, thin stipe, expanded basally into a small globose foot, 74–104 × 8–12 μ, 8-spored. Ascospores hyaline, non-septate in the ascus, cylindrical to spindle-shaped, rounded above, acute below, arranged in pairs in the terminal half of the ascus, 26–33 × 3–3.5 μ, without evident gelatinous envelopes.

Hysterotheciis atronitidis, discretis, fusiformibus, utrimque acutis, 1.2–2.3 mm. × 415–520 μ, subcuticularibus; labiis ostioli fornicatis, fortiter carbonaceis, 65–80 μ latis, usque 65 μ densis, periphysibus viridibus, clavatis, 12–15 × 1.5–3.5 μ, persistentibus et in aetate rufescentibus ornatis; tegminibus non radiantibus sed ad marginem cum cellulis terminalibus aliformibus; basibus radiantibus; paraphysibus hyalinis, filiformibus, ascos aequantibus aut excedentibus, usque 124 × 1–1.5 μ; ascis clavatis, 74–104 × 8–12 μ; ascosporis hyalinis, non septatis, cylindricis, basim acutis 26–33 × 3–3.5 μ.

Type specimen: Ellis, North America Fungi, No *464* (as *Hypoderma commune* (Fries) Duby); type locality: Westchester, Pennsylvania; host: *Eupatorium purpureum* L., on dead stems.

Hypoderma longissima sp. nov.

Hysterothecia shining black, in light gray to stramineous, unlimited, often extensive areas, oriented parallel to the stem axis, straight or rarely somewhat curved, discrete or rarely united end to end, narrowly elliptical to linear with acutely rounded ends, 1.2–4 mm. (1248–4024 μ) × 375–540 μ, subcuticular. Labia prominent, extroverted in age, heavily carbonized and opaque, up to 65 μ wide and 40 μ thick, lined on the margins by a compact mass of persistent, gelatinously agglutinated, clavately expanded, golden periphyses 8–15 μ long (up to 50 μ long at the ends) × 2–3 μ wide. Cover highly arched, carbonized above the hymenium but at the margin translucent, flattened, and closely applied to the base so as to form a flange-like border 40–70 μ wide, consisting of an outer plate of chitinized, radiately disposed, aliform mycelium thickened above the hymenium by 1 to several cells of carbonized pseudo-

parenchyma. Base a concave, translucent plate 1 cell thick, flattened at the margin with the cover, composed of radiately disposed aliform hyphae; this overlaid in the hollowed area by a cushion 5–10 μ thick of very fine, hyaline, closely interwoven hyphae from which the hymenium arises. Paraphyses abundant, hyaline, filiform, straight or flexuous, exceeding the asci and variously bent and crushed above them to form a loose, indefinite, white epithecium, up to 110 μ long, 1–1.5 μ in diameter, without apical gelatinization. Asci narrowly clavate, short- or long-stalked, acutely rounded at the apex, 65–100 × 8–12 μ, 8-spored. Ascospores hyaline, non-septate in the ascus, fusiform, obtuse distally, sub-acute at the base, usually fasciculate and in pairs, 18–24 × 2–3 μ, without a gelatinous matrix.

Hysterotheciis atronitidis, discretis, anguste ellipticis usque linearibus, ad apices acute rotundatis, subcuticularibus, 1.2–4 mm. × 375–540 μ; labiis ostioli fortiter carbonaceis, usque 65 μ latis et 40 μ densis, periphysibus aureis clavatis, 8–15 × 2–3 μ ornatis; tegminibus et basibus radiantibus, ex hyphis aliformibus compositis, ad marginem disculum 40–70 μ latum formantibus; paraphysibus hyalinis, rectis, ascos excedentibus et epithecium album formantibus, usque 110 × 1–1.5 μ; ascis anguste clavatis, ad apicem acute rotundatis, 65–100 × 8–12 μ; ascosporis hyalinis, fusiformibus, basim subacutis, non septatis, 18–24 × 2–3 μ.

Type specimen: Wilson and Seaver, Ascomycetes and Lower Fungi, No. *9;* type locality: Bronx, New York City, New York; host: Herbaceous stems, undetermined.

This material, collected by Seaver in the winter of 1906 and distributed as *Hypoderma commune* (Fries) Duby, should stand as a distinct species because of the size and shape of its hysterothecia, because of the strikingly developed and distinctive hysterothecial border, and because of hymenial distinctions.

Hypoderma pacificensis sp. nov.

Hysterothecia shining black, in tan to cinereous brown-limited spots of small to large extent, oriented parallel to the petiole axis, oval-fusiform to linear, discrete or rarely joined end to end, 1–3 mm. (1102–2912 μ) × 400–625 μ, subcuticular. Labia indistinct, carbonized and opaque, tapered at the ends, up to 100 μ wide and 80 μ thick, lined inwardly by a compact mass of bright yellow, clavately expanded, gelatinously agglutinated periphyses rather uniformly 12–15 μ long by 2.5–3 μ wide. Cover well arched, carbonized and thickened only in the labia, elsewhere translucent brown, extending near the ends of the hysterothecia as a flat plate

closely applied to and equalling or exceeding the base, composed of chitinized, radiately disposed, aliform hyphae and thickened near the labia only by 1 or 2 layers of brown, translucent pseudoparenchyma. Basal layer a concave plate of translucent, brown, radiately disposed aliform hyphae thickened along the center by 1 or 2 layers of brown, translucent pseudoparenchyma; this overlaid to a depth of 10–15 μ by a cushion of fine, hyaline, closely interwoven hyphae from which the hymenium arises. Paraphyses hyaline, filiform, flexuous, shorter than, equalling, or somewhat exceeding the asci, the longest curved, uncinate, or coiled at the tip to form a thin, loose epithecium, 60–100 μ long, 0.7–1.25 μ in diameter. Asci clavate, long- and slender-stalked, acutely rounded above, often asymmetrical in the saccate portion, 75–125, chiefly 90–100 $\times$ 7.5–12, chiefly 8–10 μ, 8-spored. Ascospores hyaline, non-septate, fusiform, curved, obtusely rounded distally, tapered and subacute basally, closely fasciculate and arranged in pairs, 20–28 $\times$ 2.5–3.5 μ, without a gelatinous matrix.

Hysterotheciis atronitidis, discretis, ovalo-fusiformibus usque linearibus, subcuticularibus, 1–3 mm. $\times$ 400–625 μ; labiis ostioli carbonaceis, usque 100 μ latis et 80 μ densis, periphysibus clavatis, vitellinis, 12–15 $\times$ 2.5–3 μ ornatis; tegminibus et basibus radiantibus, ex hyphis aliformibus compositis; paraphysibus hyalinis, filiformibus, ascos non aequantibus usque excedentibus et epithecium formantibus, 60–100 $\times$ 0.7–1.25 μ; ascis clavatis, supra acute rotundatis, 75–125 $\times$ 8–10 μ; ascosporis hyalinis, fusiformibus, curvis, basim subacutis, non septatis, 20–28 $\times$ 2.5–3.5 μ.

Type specimen: J. S. Boyce, No. *842*, July 21, 1921; type locality: Marcola, Lane County, Oregon; host: *Acer macrophyllum* Pursh, on petioles of fallen leaves; distribution: known only from the type locality (Boyce, specimen; Martin (**9**)).

This Pacific material differs strikingly from the *Hypoderma rufilabrum* on *Acer* in the Eastern States.

HYPODERMA RUFILABRUM (Berk. & Curt.) Duby (FIG. 4).

Hysterium rufilabrum Berk. & Curt. Grevillea **4**: 12. 1875.
Hypoderma rufilabrum Duby, Mém. Soc. Phys. Hist. Nat. Genève **16**: 52. *pl. 2, f. 21, a, b, c, d.* 1861.

Hysterothecia shining black, scattered without definite orientation in cream to cinereous, sunken, unlimited spots of small to large extent on twigs, discrete or variously united end to end or laterally, appearing striated, narrowly elliptical to linear with rounded or pointed ends and very irregular margins, 500–750 μ

wide, 800 μ–3 mm. long, or much longer when united, doubtfully subcuticular. Labia prominent and distinct, eventually extroverted, heavily carbonized and opaque, 65–130 μ wide, up to 60 μ thick, lined inwardly by a closely compacted mass of slender, clavately expanded, gelatinously agglutinated, bright orange, in age rufescent, long-persistent periphyses up to 25 μ long and 2.5–3 μ wide. Cover much arched or in maturity with the 2 halves nearly vertical to the base, carbonized in the labia only, elsewhere more or less translucent, consisting of an outer plate of radiately disposed brown, aliform hyphae thickened by the apposition below of 2 to several layers of brown pseudoparenchyma, very irregular at the margin and fringed by numerous loose, brown hyphal tips. Base a convex plate of radiately disposed, brown, translucent aliform hyphae thickened by apposition, above, of 1 to 3 layers of brown pseudoparenchyma; this overlaid to a depth of 20–35 μ by a closely and densely interwoven layer of fine, hyaline hyphae from which the hymenium arises. Paraphyses abundant, filiform, hyaline, equaling or slightly exceeding the asci, curved, uncinate or variously coiled or spiraled at the tips and forming a very thin, loose, shining-white epithecium, 80–150 μ long, .75–1 μ wide, without evident gelatinization. Asci clavate, long-stalked, rounded to subacute above, 75–145, chiefly 105–115 μ long, 12–18 μ wide, 8-spored. Ascospores hyaline, fusiform, curved, bluntly rounded above, tapered below and subacute, non-septate in the ascus, bicellular after emission, 20–25 $\times$ 3.5–5.0 μ, without an apparent gelatinous matrix.

Type specimens: in the Kew herbarium, according to Massee (**10**); also in the Université de Strasbourg, Institute Botanique et Jardin Botanique, labeled "*Hysterium rufilabrum, B. & C. in Acere striato. Nova Anglia, M. Curtis 1857.*" The latter, with its accompanying slide and drawings, is the material described and figured by Duby (**5**). Type locality: Uncertain. According to Berkeley (*l. c.*), South Carolina; according to Duby (**5**, p. 53), New England; according to Ellis and Everhart (**6**, p. 712), South Carolina; according to the type specimens, New England. Hosts and distribution: *Acer,* possibly *pennsylvanicum* L., the *Acer striatum* or "striped maple" of Berkeley and Curtis (*l. c.*), Duby (**5**), Massee (**10**), and Ellis and Everhart (**6**): New England (Duby (**5**) and the types); North Carolina (Ellis and Everhart (**6**), citing Ravenel). *A. spicatum* Lam.: New Hampshire (Farlow, *exs.;* Hansbrough, specimen); New York (Dearness and

House (**4**); House, specimen; Jackson (**8**); Peck (**12**); and Peck, specimen). Specimens examined: Duby's type; Reliquiae Farlowianae *127;* J. R. Hansbrough, No. *1598,* Cherry Mt., Carroll, N. H., July 25, 1932; H. D. House, Newcomb, Essex Co., N. Y., June 8, 1922 and June 20, 1923; C. H. Peck, Helderberg Mts., without date or number.

The hysterothecia of this fungus are, as noted by Massee (**10**), often oriented parallel with the host axis on small twigs; but on larger twigs they either are without orientation or stand at right angles to the axis. Ellis and Everhart (**6**) quote the ascospore length as 15 μ, evidently a translation of the .0006 measurement given by Berkeley (*l. c.*); and Massee (**10**) gives their measurements as 14–17 $\times$ 1.5 μ. Neither in the Duby specimen nor in any other have I found spores so small.

EPIDERMELLA COMMUNIS (Fries) Teh.

Material on petioles of *Cassia,* in H. W. Ravenel's Fungi Americani Exsiccati No. *323,* from Aiken, South Carolina, has in the copy available to me only sterile hysterothecia. These have the following characterization: shining black, oriented parallel to the axis of the petiole in unlimited sunken yellow to cinereous areas of variable, often large, extent, discrete or confluent end to end in long lines, straight or rarely curved, fusiform to linear with acutely rounded ends, 1–2 mm. (1248–2080 μ) long, 375–686 μ wide, subcuticular. Labia prominent, heavily carbonized, extroverted, up to 55 μ wide, lined inwardly by a persistent mass of bright orange, rufescent, gelatinously agglutinated, clavately expanded periphyses up to 10 μ long by 2.5–3 μ wide. Cover a deltoidly convex, translucent plate of red-brown, radiately disposed aliform mycelium thickened and carbonized only in the labia. Base a gray-brown, translucent, concave plate of aliform mycelium slightly less extensive longitudinally than the cover. The general appearance is not that of *E. communis.*

Epidermella Hansbroughi sp. nov.

Hysterothecia dull to shiny black, numerous, scattered in well marked but not delimited stramineous areas of small to large ex-

tent on stems, for the most part oriented parallel to the stem axis, discrete or rarely confluent end to end, oval to oblong with bluntly rounded ends, 725–1165 μ long, 270–525 μ wide, subcuticular. Labia absent as distinct structures, and the slit only doubtfully lined with periphyses. Basal layer a plate 1 cell thick, composed of loosely and radially disposed brown, clearly translucent, aliform hyphae; this overlaid to a depth of 10–25 μ by a closely woven hyaline plectenchyma composed of very fine hyphae. Cover well arched, without carbonization, translucent, outermost layer radial in disposition and aliform in structure, erose to minutely fimbriate at the margin, coextensive with the basal plate, rupturing longitudinally at maturity, 20–35 μ thick. Paraphyses hyaline, filamentous, straight or flexuous, often hamate or uncinate, abruptly swollen apically so as to terminate in a spherical enlargement, or often with several such enlargements forming a toruloid chain, not gelatinously agglutinated but exceeding the asci and thereby forming a shining white epithecium, 65–90 μ long, .75–1 μ wide. Asci long-fusiform, asymmetrically subacute at the tips, tapered from a little below the tips to long, slender stipes, 55–75 μ long, 5–6 μ wide, 8-spored. Ascospores hyaline, acicular, straight or slightly twisted within the ascus, fasciculate in the expanded distal half of the ascus and also arranged in pairs, blunt distally and tapered to an acuminate base, 20–35 μ long, 1–1.5 μ wide, cased in a hyaline, very thin, inconspicuous gelatinous matrix.

Hysterotheciis ateribus usque atronitidis, discretis, ovalibus usque oblongis, ad apices rotundatis, subcuticularibus, 725–1165 × 270–525 μ; labiis et periphysibus ostioli dubiis; tegmine non carbonacea, fortiter fornicata, ipso et basi radiantibus et ex hyphis aliformibus compositis, ad marginem minute fimbriatis; paraphysibus hyalinis, filiformibus, in apicibus bullatis et saepe bullulis toruloideis, ascos excedentibus, epithecium album formantibus, 65–90 × .75–1 μ; ascis longis fusiformibus, 55–75 × 5–6 μ; ascosporis hyalinis, acicularibus, supra obtusis, basim acuminatis, 20–35 × 1–1.5 μ, cum matrice gelatinosa inconspicua.

Type specimen: J. R. Hansbrough, No. *3069*, July 8, 1937; type locality: Everett Orchards, on the east slope of Mt. Anthony, Bennington, Vermont; host: *Rubus idaeus* L., var. *aculeatissimus* (Mey.) Reg. & Til., on dead stems.

Dr. J. R. Hansbrough, by whom the specimen was collected and communicated, records that the fungus is common locally [at the type locality] on stems of its host, that it invades them particularly near the tips, and that it is apparently entirely saprophytic.

The allocation of this new fungus in *Epidermella* is made with hesitation. It certainly is different from *Dermascia rubiicola* (Earle) Teh. and can in no way be confused with the form of *Hypoderma virgultorum* (Pers.) D. C. which Chevallier (2) segregated under the name *Lophodermium Rubi*. As noted in the description, the hysterothecium is situated subcuticularly; and both the basal plate and the cover plate are composed of aliform mycelium and are radiate with respect to the disposition of their component hyphae. However, provision made for the discharge of spores is dubiously that of the Hypodermataceae. If any primordium for an ostiole is laid down during the development of the cover plate, it has not been apparent in any of my sections; and neither labia nor periphyses have been found in matured material.

LOPHODERMINA RHODODENDRI (Schw.) Teh.

The habit of this species is to be extended to include attack on stems. A specimen from J. R. Hansbrough (No. *420*), collected at Rhododendron, Oregon, in March, 1931, is on stems of *Rhododendron californicum* Hook. Dr. Hansbrough states that it is apparently parasitic and causes dying back of the attacked twigs. In this material the ascospores differ from those hitherto observed in leaf inhabiting material in that they taper basally to needle-like points and resemble in this respect certain very long-spored species of *Hypodermella*, for example, *H. punctata* Darker and *H. Abietis-concoloris* (Mayr) Dearn.

Lophodermium Danthoniae sp. nov.

Hysterothecia black, scattered in unlimited stramineous areas along the length of leaves and sheaths, oriented parallel with and situated between the veins, narrowly to broadly elliptical with rounded to inconspicuously apiculate ends, 330–400 × 195–325 μ, subepidermal. Labia prominent, heavily carbonized, eventually completely extroverted, about 4/5 the hysterothecial length, 20–35 μ wide, somewhat erose and lined inwardly by a mass of persistent, clavately expanded, hyaline, gelatinously agglutinated periphyses 5–10 × 1–1.5 μ. Cover well arched, thin, brown, more or less translucent except in the carbonized labia, its outer plate of aliformly terminated hyphae underlaid by 1 or 2 layers of brown pseudoparenchyma. Basal layer a plate of brown, translucent,

radially disposed, aliformly terminated, irregular hyphae, occasionally thickened by 1 or 2 layers of brown pseudoparenchyma; this overlaid to a depth of 5–10 μ by a closely interwoven plectenchyma of fine, hyaline hyphae from which the hymenium arises. Paraphyses hyaline, filamentous, straight or flexuous, expanded toward the tips, becoming uncinate, bent, or crushed by pressure and gelatinously agglutinated above the asci into a shining white epithecium 3.5–5 μ thick, up to 75 μ long, 1–1.5 μ wide. Asci cylindrical-clavate, asymmetrically acute above, widest above the middle, tapered downward and abruptly narrowed near the base to a rounded foot, 45–65 × 6–7.5 μ, 8-spored. Ascospores hyaline, filiform, non-septate, of uniform diameter, fasciculate and arranged in pairs, straight or somewhat twisted with the ascus, 35–45 × 1–1.5 μ, gelatinous matrix inconspicuous.

Hysterotheciis nigris, sparsis, anguste usque late ellipticis, utrinque rotundatis vel apiculatis, subepidermalibus, 330–400 × 195–325 μ; labiis ostioli fortiter carbonaceis, 20–35 μ latis, periphysibus hyalinis, clavatis, 5–10 × 1–1.5 μ ornatis, tegmine ex hyphis aliformibus, basi ex hyphis radiantibus et aliformibus composita; paraphysibus hyalinis, filiformibus, in apicibus inflatis, ascos excedentibus, apothecium album, 3.5–5 μ densum formantibus, usque 75 × 1–1.5 μ; ascis cylindro-clavatis, 45–65 × 6–7.5 μ; ascosporis hyalinis 35–45 × 1–1.5 μ, cum matrice gelatinosa inconspicua.

Type specimen: J. J. Davis, without number, dated August 11, 1934, in the herbarium of the University of Wisconsin; type locality: Brule, Wisconsin; host: *Danthonia spicata* (L.) Beauv., on dead leaves; specimens examined: the type and G. H. Boewe, Carbondale, Illinois, April 28, 1938, Accession No. *27027* in the Illinois Natural History Survey Mycological Collection.

This species is very closely allied with *L. Airarum* (Fries) Hilitzer, from which it is distinguished by its smaller hysterothecia, shorter, narrower asci, and shorter ascospores. The level at which its hysterothecia are inserted in the host is determinable with difficulty, as often is true of other graminicolous species, because it completely disorganizes the host tissues, including epidermal cells adjacent to the hysterothecial margins, and leaves definitely intact only the cuticle. No imperfect form is present in either of the specimens.

SECTION OF APPLIED BOTANY AND PLANT PATHOLOGY,
ILLINOIS STATE NATURAL HISTORY SURVEY,
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EXPLANATION OF FIGURES

FIGS. 1–6. 1, *Hypoderma Caryae,* ascus and three septate ascospores; 2, *Clithris Rosae,* cross-section of an ascoma; 3, *Hypoderma Apocyni,* ascus with spores; 4, *Hypoderma rufilabrum,* cross-section of a hysterothecium; 5, *Clithris leucothoicola,* cross-section of an apothecium; 6, *Clithris Camelliae,* cross-section of an apothecium.

HISTOLOGICAL STUDIES OF THE BOLETACEAE AND RELATED GENERA[1]

R. P. Elrod & Dorothy L. Blanchard

(with 2 figures)

At the present time, a student of the *Boleti* has a choice between a variety of classifications, both as to systematic arrangements of the group with related groups, and as to generic make-up. These fleshy fungi have been made a subfamily of the Polyporeae (**5**), a family of the Agaricales (**8**, **10**, **13**), and a family of a new order, Boletales (**4**). This family or subfamily has been conceived of as having from one to twelve or thirteen genera. Sartory and Maire (**18**) would include all *Boleti* and *Phylloporus rhodoxanthus* in a single genus *Boletus*. Peck (**15**), Patouillard (**14**), Kallenbach (**8**) and Bresadola (**2**) present essentially the same sort of a scheme consisting of three to five genera (Peck leaving out the European *Gyrodon* and Patouillard adding *Tylopilus* to the usual four). This type of arrangement is essentially a modification of that of *Fries* (**3**), with the genera distinguished on the basis of the more obvious, superficial, macroscopic characters. The other extreme is represented by the plans of Gilbert (**4**), Singer (**20**), Konrad and Maublanc (**10**) and Murrill (**13**), which are modifications of the plan of Quélet (**16**) or Karsten (**9**). Gilbert erects the order Boletales, with two families, Paxillaceae and Boletaceae, with twelve genera in the latter, including *Phylloporus*. He stresses the microscopic characters of the spores. Singer places *Phylloporus* in the Paxillaceae, and divides the Boleti into Strobilomycetaceae and Boletaceae, with thirteen genera in the two families. These three families are members of the Agari-

[1] This paper is a summary of the more important data forming the bases of separate theses by the two authors, submitted in partial fulfillment of the requirements for the degree of Master of Science in the Department of Botany in the Graduate School of Brown University, May 1938. The investigations were carried on under the direction of Professor Walter H. Snell.

cales, with the Gomphidiaceae between the Boletaceae and Paxillaceae. Konrad and Maublanc likewise place the Paxillaceae and the Boletaceae in the Agaricales, with *Phylloporus* in the latter, and they modify Gilbert's Boletaceae by making several of the genera into subgenera of the genus *Boletus*. Murrill, in general following Karsten, suggests eleven genera distinguished on the basis of color of the spore print and presence or absence of annulus.

In view of the very plain tendency in Europe to multiply the number of genera in a family that appears to be rather homogeneous, the customary American conservatism in mycology causes one to inquire into the justification of the splitting of the old genera. The most obvious line of study is in the direction of microscopic details. This has been the procedure that has led in part at least to the production of the new systems in the Agaricaceae and apparently to a certain extent in the Boletaceae, although the published material along this line in the latter family is very meagre. Therefore, whether Americans will continue to use Peck's modification of the Friesian scheme of the Boletaceae or ought soon to adopt one of the recent European ones, it is highly desirable that detailed studies be made of the comparatively numerous and more widely diversified representatives of this family on this continent. Partially to accomplish this desideratum and in any event to continue the modest beginning made by Yates (**23**) a number of years ago, histological studies were made of the pilei of over seventy species of the *Boleti* and related agarics and the species immediately following.

FISTULINA HEPATICA

This fleshy fungus with discretely tubular hymenophore has usually been classified as a segregate in the polyporaceous group, without stated relationships to either the polypores or the boletes. Our study of it was undertaken more out of curiosity than with any idea that it was related to the latter group. In the midst of the examination of sectioned material of this fungus there came to hand the article by Lohwag and Follner (**11**) presenting histological evidence which justified them in placing the genus in the Cyphellaceae.

In general, it may be stated that the structure of *Fistulina* has

nothing in common with that of any of the Boletaceae. The upper portion of the flesh consists of hyphae arranged in a strikingly parallel manner, although lower down they tend to become somewhat interlaced. Above the tubes they are more compacted and they branch and turn down into the hymenophore in such a manner as to make no line of demarcation. The hyphae of the tube walls are strictly parallel, at the edge turning outward into the tube cavity to form the hymenium. There is no evidence of a subhymenium. The basidia are small and distinguishable only with difficulty. No cystidia were found.

In the beginning we had no interest in carrying the study farther, but in view of the conclusions of Lohwag and Follner (loc. cit.), their observations were checked. Our observations as to the origin and growth of the tubules, and the presence of conidia on the upper surface, coincide with theirs. Further, examination of certain Cyphellaceae (*Cytidia salicina, Aleurodiscus amorphus, A. Oakesii, Cyphella villosa, C. albo-violacea* and *Solenia anomala*) showed that the structure of these species and of *F. hepatica* is essentially the same, especially in the decidedly parallel arrangement of the flesh hyphae and the nature of the cups.

GOMPHIDIUS MACULATUS

In view of the general agreement that the *Gomphidii* are related to the *Paxilli* and the *Boleti*, and especially in view of Lohwag and Peringer's article (**12**) containing observations on *Gomphidius viscidus* and *G. glutinosus, G. maculatus* was studied. In tangential sections, the outermost region of the carpophore consists of tangled hyphae (cutis?) only slightly more compacted than the tissue immediately below it, but the extreme outside of which is definitely gelified, with a thin layer of gluten in places. A subcutis is scarcely distinguishable. The flesh is loose towards the outside, looser and more alveolate below and confluent with the trama of the gills, without any line of demarcation.

The gills of *G. maculatus* are thick and obtuse like those of *G. glutinosus*, not wedge-shaped as in *G. viscidus*, but tapering slightly near the edges only. The gill trama is only slightly and loosely interlaced, with a tendency toward a sub-parallel condition in many

places (FIG. 1, *a*). There is no sign of a differentiated mediostratum and laterostratum. Hence, in this respect *G. maculatus* differs decidedly from *G. glutinosus* with its definitely bilateral trama, and resembles *G. viscidus* with its trama of interlaced hyphae, although the trama of *G. maculatus* is much looser.

The subhymenium is a rather thick, subcompact layer of interlaced hyphae, like that of *G. glutinosus,* but differing from that of *G. viscidus* with its isodiametric cells.

The cystidia are abundant, irregularly cylindric, obtuse, variable, and encrusted.

THE GENUS PAXILLUS

The *Paxilli* are more closely related to the Boletaceae than are the *Gomphidii.* A rather complete discussion of the history of the classification of the *Paxilli* has been given by Gilbert (**4**, pp. 64–69), and his final conclusions are of more than passing interest.

Of the five species of *Paxilli* (with the American *P. corrugatus* the only species not common to both continents), Gilbert makes the following arrangement: *Tapinella panuoides* (Fries) Gilbert, *T. corrugatus* (Atk.) Gilbert and presumably *Paxillopsis atrotomentosus* (Fries ex Batsch) Gilbert in the Agaricaceae; *Paxillus involutus* Fries ex Batsch in the Paxillaceae of the Boletales; and *Phylloporus rhodoxanthus* (Schw.) Bres. in the Boletaceae. Most of the modern workers accept the latter genus as distinct, and many furthermore would place it in the Boletaceae, but they consider the other four species as belonging in *Paxillus* [cf. Konrad and Maublanc (**10**), Josserand (**7**), Romagnesi (**17**) and Kühner (correspondence with Snell)].

Our studies of the four *Paxilli* may be summarized as follows.

There is no definite cutis in any of the species, although the outer layers of all are slightly compacted. This layer is thick in *P. atrotomentosus* and thin in the other three species.

In all species there are structural features that make for the characteristic ready separability of the gills from the flesh, but there is one difference. In *P. panuoides,* there is a distinct change of direction of the hyphae as they proceed from the flesh into the gills, with a definite line of demarcation between the two, while in the other three species the flesh is in general loose and slightly staining, but quite compact just above the gill layer.

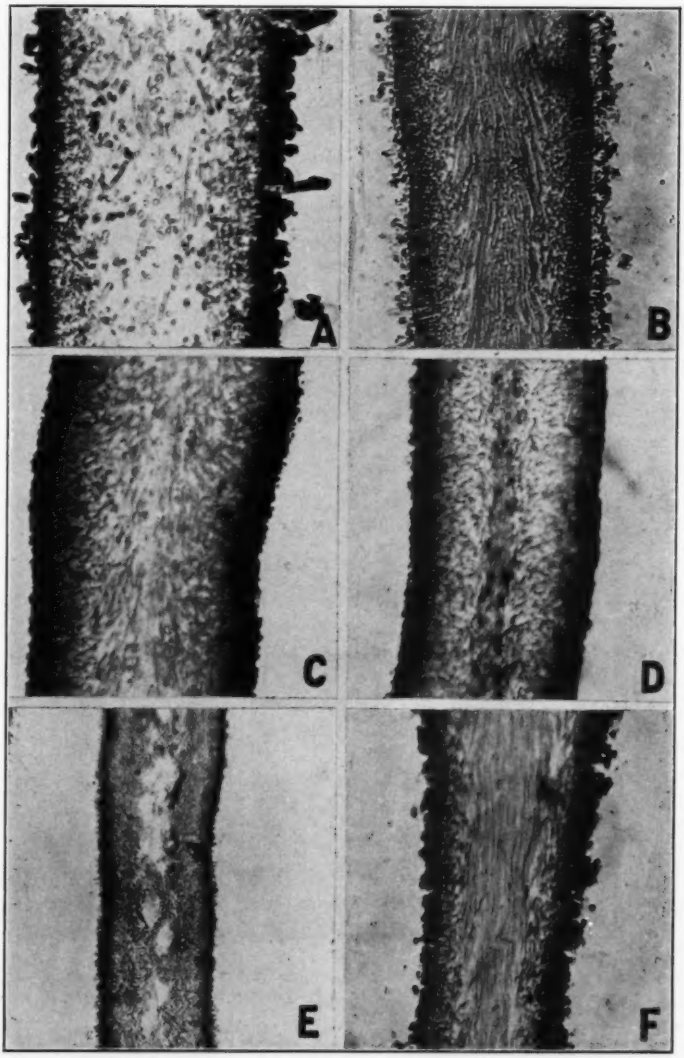

FIG. 1. *A, Gomphidius maculatus; B, Phylloporus rhodoxanthus; C, Paxillus atrotomentosus; D, P. panuoides; E, P. corrugatus; F, P. involutus;* all × 110.

The gill trama is definitely bilateral in *P. atrotomentosus* (FIG. 1, *c*) and *P. panuoides* (FIG. 1, *d*) but only indefinitely if at all so in *P. corrugatus* (FIG. 1, *e*) and *P. involutus* (FIG. 1, *f*), although Josserand states that it is bilateral in *P. involutus* (**7**).

The spores of all four species are of the same shape, varying only in size from larger to smaller as follows: *P. involutus, P. atrotomentosus, P. panuoides* and *P. corrugatus.*

Cystidia are common in *P. involutus,* but absent in the other three species.

Hence, it seems that histological details offer no consistent basis for a segregation of these species in different genera.

PHYLLOPORUS RHODOXANTHUS

This species has a well defined, compacted, darkly staining, thin cutis. The flesh is coarser than in any of the *Paxilli.* The hyphae of the flesh change direction more or less gradually into the gill trama, without any distinct line of demarcation between the two. Hence, the gills of this species ought not to be as readily separable as in *Paxillus.* The trama is composed of a very slightly interlaced mediostratum distinguished with difficulty from the lateral stratum of parallel hyphae (FIG. 1, *b*). The cystidia are broadly lanceolate and exceedingly abundant. Hence, this species is structurally different from the *Paxilli* and quite similar to the *Boleti* in sufficient details to support the contentions of those who prefer to place it in the Boletaceae.

POLYPOROLETUS SUBLIVIDUS

This species has a plainly visible trichoderm of tomentum 240 μ thick. The flesh consists of loosely interlaced hyphae down to just above the tubes, where it is compact, with the hyphae running radially and almost parallel. The trama is made up of interlaced hyphae of small diameter and hence is not bilateral. This subhymenium is thin and hardly distinguishable. The basidia are broadly elliptical, $20 \times 10\,\mu$, with four sterigmata that are long, tubular and wavy, tapering only at the tips. Cystidia were reported by Snell (**22**), but were not found in our prepared sections.

STROBILOMYCES STROBILACEUS

This species has a rather distinct cutis, which is covered by thick, tomentose scales. The flesh is very loose and alveolate, appearing spongy. The hyphae of the flesh branch off inconspicuously to form a thin, more or less simple trama of parallel hyphae with no differentiation into mediostratum and laterostratum. The subhymenium is so thin as to be hardly distinguishable. The basidia are clavate-cylindric, short-sterigmate, 26–40 × 6–9 μ. Large, ventricose-lanceolate cystidia are abundant and prominent on the tube walls, but scarce at the mouths.

THE GENUS BOLETINUS

Of the eight species of this genus studied, *B. castanellus* has an unadorned cutis, while *B. spectabilis* and *B. pictus* have a more or less definite cutis adorned with clumps of hyphae which form the characteristic scales. *B. glandulosus* has an ixotrichoderm,[2] and *B. cavipes, B. porosus* and *B. squarrosoides* have a trichoderm. In *B. paluster* the covering is more or less flocculose, and in *B. porosus* it may be almost a pile at times.

The flesh of the species examined offers nothing worthy of note, except that in *B. cavipes* there are small, yellow, warted, globular bodies of unknown origin or significance, and that sap hyphae are found in *B. spectabilis*. In none of the species is there any pronounced change of direction of the hyphae from the flesh into the hymenophore and no difference in compactness, etc., between the two portions, except in *B. glandulosus,* in which the hyphae of the hymenophore are somewhat finer and slightly more compact. This general situation is what one would expect, because the tubes of *Boletinus* are separable only with difficulty, if at all.

The tube trama is variable in the species studied. It is bilateral

[2] In the course of these studies Professor Snell coined the term "ixoderm" to describe the gelifying surface layer, and defined it as follows: "a covering of the pileus originally made up of more or less erect, somewhat wavy and more or less interlaced hyphal ends of some length, which later gelify to a greater or lesser degree, to make the surface viscid, viscous or slimy." Lohwag, in correspondence with Professor Snell, suggested that "ixotrichoderm" would be much more precise and Professor Snell accepted the suggestion.

part way down the tubes in *B. glandulosus* (FIG. 2, *a*) and in *B. porosus* (FIG. 2, *b*), and otherwise divergent at the edges; indefinitely bilateral in *B. squarrosoides* and in places in *B. spectabilis;* made up of parallel hyphae in *B. castanellus* (FIG. 2, *c*), *B. paluster* and *B. pictus,* and also for the most part in *B. spectabilis;* and made up of interlaced hyphae in *B. cavipes* (FIG. 2, *d*).

The cystidia are generally cylindrical, clavate or fusiform, with only a few ventricose-rostrate, and single or clustered on the tube walls and at the mouths.

BOLETINUS AND BOLETINELLUS

The genus *Boletinellus* was established by Murrill (**13**), with a characterization but with no discussion or explanation as to the reason for making a new genus. In this latter genus he included *B. merulioides* (*porosus*), although in his keys he separated them as *Boletinus,* annulate, and *Boletinellus,* exannulate.

It so happens that *Boletinus grisellus* and *B. appendiculatus* have no annulus, while *Boletinellus paluster,* with a definite veil when young, often has more that could be called an annulus than either of the foregoing.

Gilbert (**4**), however, accepts the distinction between the two genera, including *B. porosus* and *B. paluster* in *Boletinellus* [with some misgivings about *B. paluster* (correspondence)], but on the basis of the shortness of the tubes, slightly shorter spores and difference in the color of the spore prints, and not on histological differences. In an article which has appeared since our studies were made, Singer (**21**) likewise accepts the distinction, but includes *Boletinellus* in *Gyrodon,* with *Phylloporus* between *Boletinus* and *Gyrodon.* He places *B. porosus* (*merulioides*) and *B. castanellus* in *Gyrodon, B. rhodoxanthus* and *B. squarrosoides* in *Phylloporus,* and the remaining species in *Boletinus.* These realignments are made at least partially on the basis of microscopic details, but histological features of the species offer no support.

THE GENUS BOLETUS

The Covering of the Pileus

A definite trichoderm is present in: Subpruinosi—*B. pallidus;* Subtomentosi—*B. chrysenteron, B. chrysenteroides, B. subtomen-*

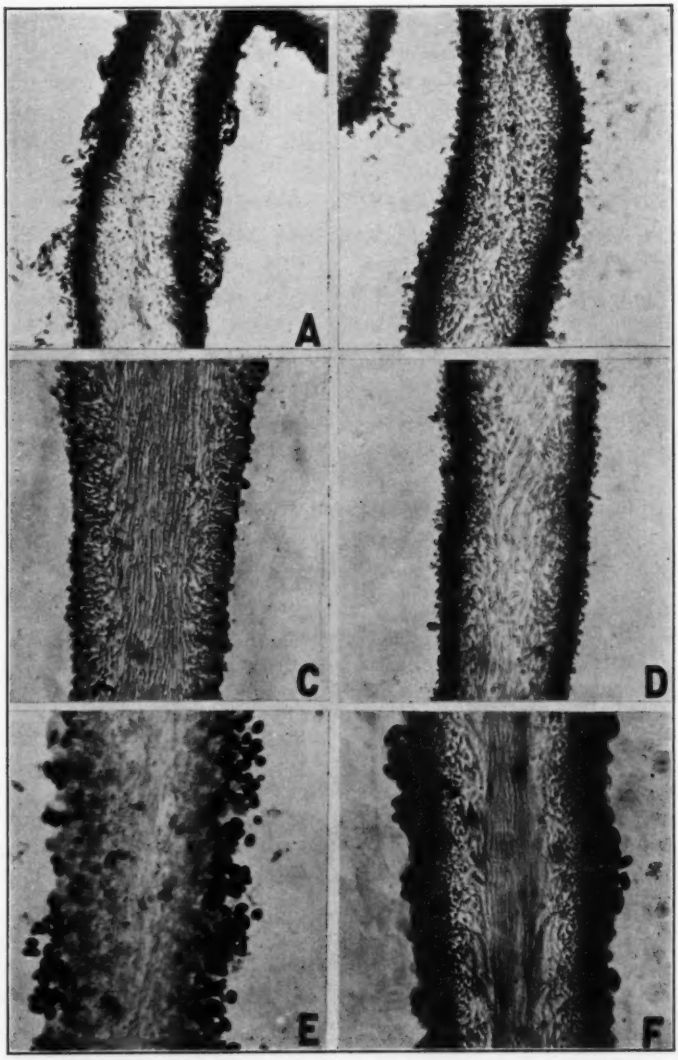

FIG. 2. *A, Boletinus glandulosus; B, B. porosus; C, B. castanellus; D, B. cavipes; E, Boletus Russellii; F, B. Betula;* all × 110.

tosus; Laceripedes—*B. Russellii,* apparently the remains of one in *B. Betula;* Calopodes—*B. Peckii, B. griseus, B. illudens;* Luridi —*B. luridus, B. erythropus, B. vermiculosus* (in part); Edules —*B. auripes, B. variipes, B. subdecorus;* Versipelles—*B. leucophaeus;* Hyporhodii—*B. alboater* (in part), *B. felleus;* Cariosi —*B. castaneus, B. cyanescens;* Favosi—*B. porphyrosporus.*

It is rather striking that fewer species of *Boletus* than would be expected have a cutis, because so many are glabrous. The situation may be the result of choice of species, inasmuch as only 54 of the 150-odd species of the family were available for study. Furthermore, a cutis was found in the most unexpected species. The list follows: Viscipelles—*B. subaureus, B. hirtellus, B. piperatus* (instead of an ixotrichoderm, which may have been washed away); Pulverulenti—*B. Ravenelii;* Subpruinosi—*B. roseotinctus, B. rugosiceps* (?), *B. alutaceus;* Subtomentosi—*B. subtomentosus* (beneath the trichoderm); Calopodes—*B. modestus;* Luridi—*B. vermiculosus* (more or less), *B. eccentricus;* Versipelles—*B. versipellis;* Hyporhodii—*B. indecisus, B. gracilis* (a pseudocutis). There is no true cutis in *B. miniato-olivaceus*—only a compacted outer flesh.

An ixotrichoderm is present in most of the Viscipelles as would be expected, although it is to be noted that three species in the preceding paragraph did not have one in the specimens examined. Such a covering is found likewise in *B. Betula* (Laceripedes) and *B. Frostii* (Luridi).

An epithele is present in *B. scaber,* as was noted by Imler (**6**), and it affords a good means of distinguishing this species from *B. aurantiacus, B. versipellis* and *B. niveus.* This type of covering occurs also in *B. subglabripes* (Subpruinosi) and apparently, strangely enough, in *B. rubeus* of the Subtomentosi.

Bataille (**1**) erected the genus *Phaeoporus* for *Boletus porphyrosporus* on the basis of the velvety or pilose clothing of the pileus and stipe. Gilbert (**4**, p. 74) considers this separation as necessary and quotes Kühner (p. 75) as considering the maintenance of this genus as indispensable, because of what they consider an unusual type of pileus clothing in the Boletaceae. Gilbert, however, recognizes that the name *Phaeoporus* is preoccupied as one of the genera of the Polyporaceae created by Schroeter,

and suggests in its place the name *Porphyrellus.* If one is to split up the genus *Boletus* according to any of the many schemes proposed by European mycologists, there is good basis for this genus, but it remains to be seen as to how many other American species will have to be included if the genus is accepted. Such an acceptance may result in difficulties. It would be natural to include *B. fumosipes* with its pilose covering and more or less reddish spores. On the other hand, it is found that *Boletinus porosus* is more or less pilose in certain portions of the mature pileus and that *Boletus variipes* and *B. impolitus* of the Edules and *B. alboater* of the Hyporhodii are pilose in varying degrees, the latter especially when young. Also, there are other less well understood species or varieties, such as those which Snell (**22**) has described as var. *rubrobrunneus* and var. *plumbeoviolaceus* of *B. felleus,* that are velvety to pilose.

FLESH

There is nothing of value to be obtained from the flesh characters. In our sections of the pileus this portion varies from species to species within groups and there is no question but that it would vary from specimen to specimen of the same species, depending upon the maturity of the specimen. One thing of interest, however, is the presence of the yellow, globose bodies, warted in most of the species. What they are or what their origin is, cannot be stated. These occur in abundance in *Boletus americanus, B. placidus* and *B. piperatus* of the Viscipelles, in *B. roseotinctus* of the Subpruinosi, and in *B. castaneus* and *B. cyanescens* of the Cariosi.

SAP HYPHAE

Inasmuch as Lohwag and Follner (loc. cit.) paid considerable attention to the sap hyphae in the Boletaceae which they studied, these structures were noted in the present investigations in order to find out whether or not the presence or absence of them has any significance in the separation of the various groups, subgenera or genera, as the case may be.

In the Viscipelles of the genus *Boletus,* only *B. piperatus* among

the species investigated possesses them. The one species of the Pulverulenti studied, both species of the Laceripedes and two of the three species of the Cariosi do not have them, but in all the other groups there was no uniformity. In the Versipelles, *B. versipellis* has them in abundance, while the other species do not have them; in the remaining groups they occurred in about half the species.

BILATERALITY OF THE TRAMA

Although Lohwag and Peringer (loc. cit.) made much of the study of the nature of the trama, there seems to be no need here to be specific concerning this tissue.

Of 46 species of the genus *Boletus* studied, about half possess a trama that is distinctly bilateral or questionably so, while a good half of them show a uniform trama, whether of parallel or of interlaced hyphae. Within the groups (or the proposed new genera), the situation is the same. Of the four species of Versipelles studied, not one has a bilateral trama. In the Hyporhodii, all but one species studied has at least a questionably bilateral trama. In the Cariosi, *B. castaneus* has a definitely bilateral trama, but *B. cyanescens* has one which is definitely not. In the Laceripedes *B. Betula* has a definitely bilateral trama (FIG. 2, *f*) while that of *B. Russellii* is not bilateral (FIG. 2, *e*). Hence, unless younger stages provided more definite results, it seems that this character is of no importance in the taxonomy of this group of fungi, as was stated by Sauger (**19**). Lohwag and Follner (**11**) did not go so far as to make such a statement but they said that the bilaterality was of irregular occurrence in the Boletaceae.

CYSTIDIA

In the Viscipelles, the cystidia are mostly cylindrical-clavate, a few fusiform. We found none ventricose-rostrate, although Snell in his private notes records some in some species. In *B. piperatus,* they are entirely fusiform, a condition different from that in any other species of the group, but this species is aberrant in several respects and apparently represents a connecting link between the Viscipelles and following groups.

In the Subpruinosi, the cystidia are clavate, fusiform or ventricose-rostrate, while in the Subtomentosi they are fusiform to ventricose-rostrate. In the Calopodes, Luridi and Favosi, they are usually ventricose-rostrate, while in the Edules they tend more toward the fusiform.

In the Versipelles, they are rare in *B. scaber,* but abundant in the other three species studied. They are mostly ventricose-rostrate in shape, with some fusiform.

In the Hyporhodii they are rare or lacking in three species but very abundant and unusual in *B. indecisus.* Where present, they are fusiform to ventricose-rostrate.

In the Cariosi, they are rare or lacking on the tube walls, but at the mouths are clavate to subfusiform to ventricose-rostrate.

CYSTIDIA IN THE BOLETACEAE

In general, concerning the cystidia in the Boletaceae, the following points may be noted. In *Phylloporus,* they are mostly fusiform or broadly lanceolate, with a few clavate or somewhat ventricose-rostrate. In *Polyporoletus,* none were found by us, but the questionable ones found by Snell were fusiform. The one species of *Strobilomyces* has fusiform cystidia and those in the Edules tend more to the fusiform. *Boletinus* and the Viscipelles of the genus *Boletus* have very similar cystidia (cylindrical-clavate), and this fact only further bears out the generally recognized relationship of the two segregates. In the remaining groups, it may be seen that in the order in which they occur in the Peckian classification, the groups tend progressively to have a greater proportion of the ventricose-rostrate type, with these predominating in the later groups. What this means phylogenetically is a question..

In general, however, it may be said that from the point of view of the taxonomy of the Boletaceae, the cystidia offer no assistance in connection with generic concepts,[3] except possibly the rarity or lack of them on the walls of the Cariosi (genus *Gyroporus*), and that they assist in the determination of species in only a few cases. Sauger (**19**) stated that they have less value for genera

[3] *Cf.* Singer (**21**), however, whose paper appeared after this work was completed.

and species than the spore, that their value is debatable because of their variation in abundance and distribution, and that they are not to be considered as having critical value as a basis for species.

GENERAL CONCLUSIONS

From the present histological study of the pilei of nearly half of the American species of the Boletaceae, it would seem that details of structure have little significance either in the older conceptions of the genera with their subgroups, or in the more recent generic segregates, except to a certain extent in *Polyporoletus* and *Strobilomyces* and possibly in part in the pilose genus *Porphyrellus*. In the *Boletinus* and *Boletus* complexes there is no group consistency in the types of covering or clothing of the pileus, flesh characters, sap hyphae or bilaterality of the tube trama. The differences in the cystidia offer assistance only in general or in a few particular instances. Of course, it is necessary to realize that the studies are not complete. Perhaps the study of more of the species will serve to emphasize small differences between genera. Only the pilei have been treated here and even this organ possibly not sufficiently minutely. For example, Singer (**21**) makes much of differences in the cystidia of the *Boletinus* complex which were not considered in this work.

On the other hand, even on the basis of present progress, histological details are of great value in the elucidation of the problems of species complexes and in the establishment of species concepts. Much clarification of old difficulties has been brought about in recent years through this method of attack.

SUMMARY

Histological studies have been made of the pilei of over sixty species of the Boletaceae and a few related species, such as *Gomphidius maculatus,* the *Paxilli* and *Phylloporus rhodoxanthus. Fistulina hepatica* was likewise included. The features studied were the clothing of the pileus, the flesh, sap hyphae, nature of the tube trama (especially of the bilaterality or lack of it), and the cystidia.

Fistulina hepatica is structurally different from the other species studied, as has been pointed out before.

Gomphidius maculatus is contrasted with other species of the genus.

Structural details of the *Paxilli* offer no basis for segregation of the species in different genera or in different families.

Phylloporus rhodoxanthus is structurally different from the *Paxilli* and sufficiently similar to the *Boleti* to justify placing it in the Boletaceae, if on other grounds this disposition of it appears desirable.

In *Boletinus* and in *Boletus* and its subgroups in the Peckian scheme, on the basis of information available at present, histological details appear to be of little significance for the making of generic or group distinctions. They are, however, of value in solving problems of species and in the establishment of species concepts.

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EXPLANATION OF FIGURES

FIG. 1. Cross sections of lamellae. *a, Gomphidius maculatus,* with undifferentiated, interlaced trama. *b, Phylloporus rhodoxanthus,* with divergent type of trama hardly differentiated in the mediostratum and laterostratum. *c, Paxillus atrotomentosus,* with indistinctly bilateral trama. *d, P. panuoides,* with definitely bilateral trama, showing distinct mediostratum and laterostratum. *e, P. corrugatus,* with trama hardly bilateral if at all so. *f, P. involutus,* with parallel trama. All × 110.

FIG. 2. Longitudinal sections of tube walls. *a, Boletinus glandulosus,* and *b, Boletinus porosus,* with trama bilateral part way down, and divergent below. *c, Boletinus castanellus,* with trama of parallel hyphae. *d, Boletinus cavipes* with trama of interlaced hyphae. *e, Boletus Russellii,* with trama of interlaced hyphae. *f, Boletus Betula,* with definitely bilateral trama. All × 110.

STUDIES ON ASCOSPORE VARIANTS OF HYPOMYCES IPOMOEAE

A. W. DIMOCK *

(WITH 6 FIGURES)

The writer has alluded in earlier papers (**1**, **2**) to certain variant strains which originated as the primary growth from single ascospores isolated from *normal* × *normal* and *normal* × *aborta* perithecia of *Hypomyces Ipomoeae* (Hals.) Wr. These strains were designated as "ascospore variants" (**3**) to distinguish them from the "natural variants" and "induced variants" which had their origin in the gametophytic mycelium of the *normal* strain. While studies on these ascospore variants were somewhat limited, the results were so striking and suggestive that a more detailed review is here presented.

THE PURPLE VARIANT

First to be considered is the *purple* variant which appeared in the progeny of both *normal* × *normal* and *normal* × *aborta* perithecia (**1**, **2**). The variant differs from *normal* in the development of purple pigment in hyphae and culture medium, in the production of fewer microcondia, in the lack of tan macroconidium masses at the colony centers, and in weaker sex-reaction (FIG. 1*a*). The strain develops no perithecial fundaments, and although producing perithecia readily when mated with *normal*, produces very few when inbred. A total of 46 pure *purple* cultures appeared in a population of 485 single-ascospore cultures obtained from 6 *normal* inbred and 6 *normal* × *aborta* perithecia. In addition, sectors of *purple* growth appeared in two of the cultures of the *normal* type obtained from perithecium E1, one originating at the inoculum, the other apparently originating at a point 15 m.m. distant from the inoculum. The distribution of *purple*

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variants and sex-reaction groups in the single-ascospore populations are indicated in Table 1. The two *normal* cultures which

TABLE 1

DISTRIBUTION OF *purple* VARIANTS AND SEX-REACTION GROUPS IN THE PROGENY OF *normal* × *normal* (E) AND *normal* × *aborta* (T) PERITHECIA

Perithecium	*purple*		*normal* [a]		Per cent *purple*
	a	*A*	*a*	*A*	
E1	3	1	5	11	20 [b]
E2	1	1	15	11	7
E3	1	0	25	11	3
E4	4	5	4	7	45
E6	0	0	23	28	0
E7	0	0	8	10	0
T3	1	1	24	36	3
T4	0	0	5	3	0
T5	8	0	25	19	15
T6	7	10	58	43	16 [c]
T7	1	2	22	18	7
T8	0	0	10	16	0
Total	26	20	224	213	10

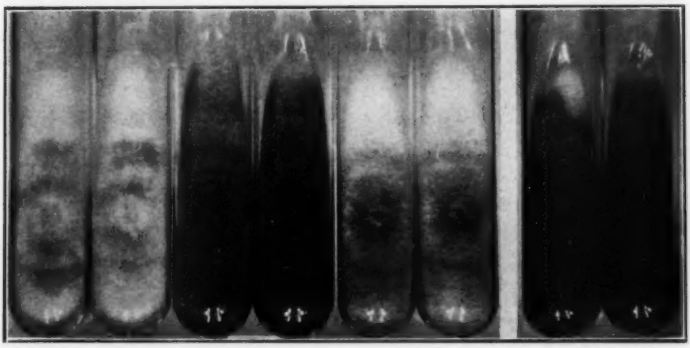
[a] Includes both *normal* types and ascospore variants other than *purple*.
[b] Includes 2 "mixed" cultures.
[c] Includes 2 *purple* variants of undetermined sex-reaction group.

possessed *purple* sectors, both of which bore sex-reaction factor *a*, are considered as *purple*. The sex-reactions of two of the *purple* cultures obtained from perithecium T6 were not determined.

It is seen that with the exception of perithecium E4, the percentage of *purple* variants in the progeny of any single perithecium is too low to be explained by the assumption of a unifactorial difference for the *purple* character in the parent cultures. Furthermore, the *purple* character has never appeared in any of the hundreds of mass-transfer or single-microconidium cultures of the parent strains which have been studied in this work. Perithecium E4 is believed to have been a secondary perithecium which developed as the result of spermatization of a *normal* perithecial fundament by a *purple* ascospore expelled from a primary perithecium in the same culture tube. Both E3 and E4 were taken at the same time from a culture tube mating of the *normal* tester strains (3–3, *A* and 3–14, *a*). E3 was an old perithecium exuding

ascospores, whereas E4 was an adjacent perithecium which contained a relatively small number of mature asci and whose ostiole had not yet opened.

Single-ascospore isolations were made from three *normal* × *purple* back-cross perithecia. The developing mycelia were classified as to phenotype, and the sex-reaction groups of the *normal* cultures were determined. The results are given in Table 2.



a *b*

FIG. 1. *a*, Two single-conidium cultures each of *normal*, *purple*, and a "reverted" strain obtained from a *purple* culture. *b*, Sector of "reverted" mycelium in the *purple* growth at the top of a single-conidium culture of the *purple* strain.

TABLE 2

Normal × *purple* BACK-CROSSES

Perithecium	*purple*	*normal*		Per cent *purple*
		a	*A*	
P1 (*normal*, *A* × *purple*, *a*) . .	18	7	4	62
P2 (*normal*, *a* × *purple*, *A*) . .	10	7	29	22
P3 (*normal*, *A* × *purple*, *a*) . .	13	6	4	57
Total	41	20	37	42

While populations are too small to permit extensive conclusions, it appears that the phenotypic expression of the variant is controlled by genetic factors. Furthermore, it is indicated that a single allelomorphic pair which segregates independent of the sex-

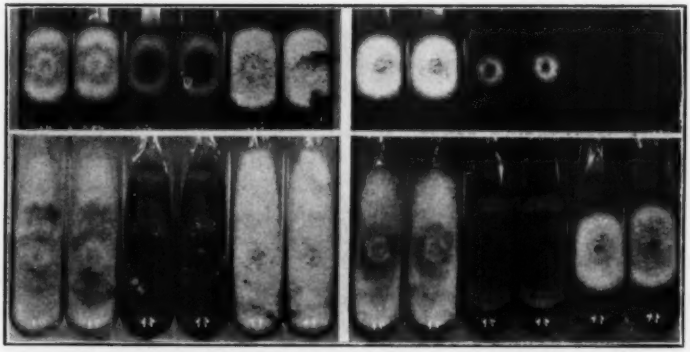
reaction factors is involved, though more detailed work would be required to check this point.

Single-ascospore isolations were made from a single *purple* × *purple* perithecium, and of the resulting cultures 25 were *purple* and 15 were *normal*. Seven of the *normal* cultures bore the sex-reaction factor *A*, eight the factor *a*. The sex-reaction groups of the *purple* cultures were not determined. The large number of *normal* cultures in this population of 40 indicates either that the *purple* factor or factors had reverted to *normal* in one of the parent mycelia prior to perithecium formation, or that there had been a high percentage of reversion to *normal* during the maturation divisions in the asci. The former assumption is favored by the facts that perithecial fundaments were never observed in pure *purple* cultures and that sectors of "reverted" growth did appear in occasional *purple* cultures (FIG. 1*b*). Mass transfers from one such sector yielded cultures appearing very much like *normal*, though single-spore cultures made from one of the latter showed that while the change had been "in the direction" of *normal*, the reversion was not quite complete (FIG. 1*a*). The suggestion that the reversion occurred during the maturation divisions in the asci is favored by the fact that the original mutations from *normal* to *purple* undoubtedly occurred during meiosis.

Somewhat similar variants in *Neurospora* have been reported by Lindegren (**6**, **7**) and by Wülker (**8**). The former found a tan variant of *N. crassa* to be conditioned by factors which exhibited considerable instability. The latter has shown a similar condition to exist with factors (*L*/*l*) for presence or lack of aerial mycelium in a strain of *N. sitophila*. Both workers showed by single ascus analysis that reversion may occur as the result of monogenic conversion during the maturation divisions in the ascus. Wülker also noted mutation of the factor *l* to *L* in vegetative mycelium. Unfortunately, single ascus analysis has not been possible in the present work, so that information concerning the frequency of conversion of the *purple* factor (or factor-group) in the maturation divisions is lacking. The writer is inclined to the opinion that the factors involved are quite labile and that, as in *Neurospora*, conversion is favored during the maturation divisions.

THE VINIFERA AND ALBA VARIANTS

Among the single-ascospore progeny of the *normal* × *normal* perithecium E3, appeared one culture which showed striking differences from *normal*. The initial growth-rate was so much slower than *normal* that the spore was nearly discarded as dead. The growth-rate soon increased, however, and after a few days the culture possessed a leathery basal structure, became strongly fluted at the center, and developed a marked greyish-purple pig-



a *b*

FIG. 2. *a*, Two single-conidium cultures each of *normal*, *vinifera*, and *alba*. Upper, 4 days old; lower, 9 days old. *b*, f_1 gametophytes from a *normal* × *vinifera* perithecium. Left to right: 2 *normal*, 2 *vinifera*, and 2 slow-germinating mycelia which later developed apparently *normal* growth. Upper, 2 days old; lower, 7 days old.

ment both in the mycelium and in the medium (FIG. 2*a*). The mycelium produced very few conidia, and those only after the lapse of a week or more. Perithecium formation, which occurred in back-crosses with the *normal* tester-strain 3–3(*A*), was considerably slower than in matings of the two *normal* strains. The variant will be called *vinifera*.

Nineteen single ascospores were isolated from a *normal* (*A*) × *vinifera* (*a*) perithecium. Eight of these developed *vinifera* cultures, and nine developed *normal* cultures, while two produced almost no growth until three days had elapsed, but eventually developed apparently *normal* cultures (FIG. 2*b*). Of the eleven

normal cultures, three possessed the sex-reaction factor *A*, eight the factor *a*. Of the *vinifera* cultures, two were found to bear the factor *A*, and two the factor *a*. The sex-reactions of the remaining four *vinifera* cultures were not determined.

No sign of reversion appeared in the original single-ascospore culture or in mass-transfer sub-cultures of the *vinifera* strain. Fifteen single-microconidium cultures were made from the original culture, however, and of these only four developed *vinifera* mycelia, while the other eleven developed an entirely new type. The new type, *alba*, was almost devoid of pigmentation, the mycelium forming a snowy mass (FIG. 2*a*). Growth-rate was about as in the *normal* strains, but conidium production was as limited as in the *vinifera* strain. The new strain proved quite constant in mass-transfer and single-conidium cultures. The nature of the change suggests that again a reversion "in the direction" of the *normal* had occurred.

Thirty-two single-ascospores were isolated from a *normal* (*A*) × *alba* (*a*) perithecium. Fourteen developed *normal* cultures, ten developed *alba* cultures, seven developed *vinifera* cultures, and one developed another variant type, *restricta*, which will be discussed later. The distribution of sex-reaction factors was found to be as follows:

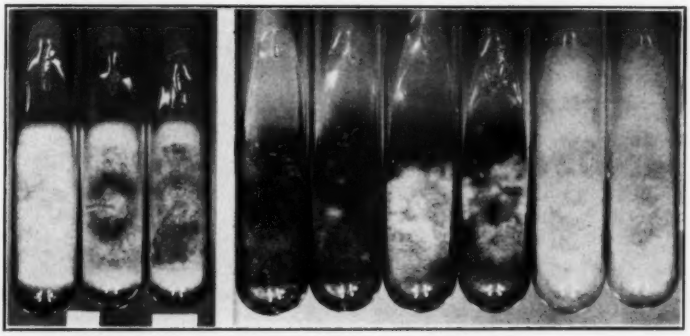
	normal	*alba*	*vinifera*	*restricta*
A:	5	2	3	1
a:	9	8	4	0

The populations, though small, serve to indicate that *vinifera* differs from *normal* in a single factor or closely linked factor-group. *Alba* may have arisen from *vinifera* either by further mutation of the *vinifera* gene (the suggested reversion "in the direction" of *normal*) or by mutation of an independent gene. The second possibility is perhaps best in keeping with the observed fact that *vinifera* may reappear in the progeny of *normal* × *alba* matings. Thus, if the *alba* phenotype were governed by an *alba* gene operative only when present with the non-linked or only loosely linked *vinifera* gene, the appearance of *normal*, *vinifera*, and *alba* in an approximate 2:1:1 ratio would be expected in the progeny of an *alba* × *normal* mating. The *restricta* culture is not believed

to be an expression of any arrangement of *vinifera* or *alba* genes. It is evident that the *vinifera* and *alba* genes are not linked to the sex-reaction genes.

THE ALBIDA VARIANT

This variant originated from a single ascospore in a population of sixty-two obtained from a *normal* × *aborta* perithecium. The appearance of the culture did not differ strikingly from the *normal*, and closely resembled the *alba* type in its abundance of snowy-white



a *b*

FIG. 3. *a*, Left to right: typical *albida* variant, "reverted" mycelium obtained from a pure *albida* culture, and *normal* tester-strain. *b*, f_1 gametophytes from a *normal* × *albida* perithecium; 4 gametophytes of the striking aberrant type on the left, and 2 *normal* gametophytes on the right. Note the "reverted" mycelium developing irregularly in the aberrant tubes.

mycelium (FIG. 3*a*). Ten single-microconidium cultures of the *albida* strain were obtained from the original culture two weeks after its isolation, and ten more were obtained from the same culture four weeks later. Of the first series, nine were of the *albida* type and one *normal*, while of the second series, nine were *normal* and only one *albida*. The *normal* cultures were almost indistinguishable from a comparable series of *normal* tester-strain cultures (FIG. 3*a*). Thus another ascospore variant showed almost complete reversion to *normal*.

Twenty-two single-ascospore cultures were obtained from a *normal* (*A*) × *albida* (*a*) perithecium. This progeny yielded most

unusual results. Twelve of the ascospores gave rise to *normal* cultures, one gave rise to a culture of the *restricta* type, and the remaining nine developed cultures of an entirely new type whose initial growth, though of almost *normal* growth-rate, was so sparse as to be detectable only when the slopes were properly inclined to the light. Eventually, however, the growth of these aberrant cultures became denser and produced a brick-red pigmentation of the hyphae and considerable pigmentation of the medium. Soon patches or aerial sectors, and marginal sectors, apparently of *normal* growth, appeared on all these colonies (FIG. 3*b*). Although detailed studies of these cultures were not carried out, it was observed that in transfers made from the tubes to fresh agar slopes for sex-reaction tests, some gave rise to apparently *normal* cultures and others yielded cultures resembling their own original growth. It should be noted that not one of the twenty-two single-ascospore cultures bore any resemblance to the *albida* parent.

Tests for sex-reaction groups showed that eleven of the *normal* cultures possessed the factor *a*, and only one the factor *A*. Of the new-type cultures, three bore the factor *a*, and four the factor *A*. The sex-reactions of the remaining two new-type cultures and of the *restricta* culture were not determined.

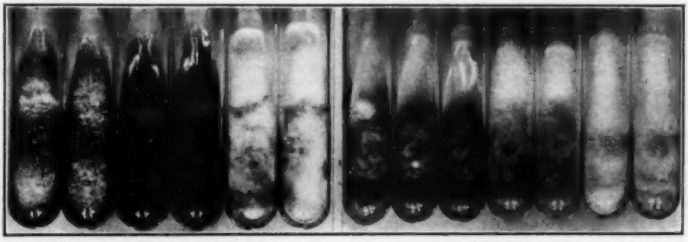
While these results have yielded little information concerning the nature of the *albida* variant, it is evident that it is exceedingly labile, and that its intrinsic differences from *normal* effect profound disturbances in the hereditary mechanism within hybrid (*normal* × *albida*) asci.

THE CONVOLUTA VARIANT

The *convoluta* variant originated as one of eight single-ascospore cultures from a *normal* × *aborta* perithecium. Growth of *convoluta* mycelium was very slow, but not sparse. The basal mycelium formed a leathery layer, and the center of the colony became markedly raised and convoluted. After the colony had attained a diameter of three to four centimeters (on potato-dextrose agar), growth apparently ceased, but eventually marginal growth was resumed, either quite regularly, or as sectors, and the entire surface of the slope became covered (FIG. 4*a*). The mycelium early took on a strong purplish hue, and considerable purple pig-

ment was diffused into the medium. Conidium production was very weak, as in the *vinifera* variant previously discussed.

Nine single-conidium cultures obtained from the original single-ascospore mycelium developed true to the *convoluta* type. Following the primary growth period one of the cultures developed particularly well marked sectors of secondary growth. One of these was fluffy and white, and bore numerous conidia, strongly resembling the *normal* type. The other was composed of very sparse, resupinate hyphae. Two mass-transfers were made from each sector, from the central growth of the same culture, and from



a *b*

FIG. 4. *a*, 13-day-old cultures obtained from one single-conidium culture of the *convoluta* strain. Left to right: 2 transfers from central *convoluta* mycelium, 2 transfers from a sector which developed at the top of the primary *convoluta* mycelium, and 2 transfers from a "reverted" sector at the bottom of the primary *convoluta* growth (see text). *b*, Left to right: 3 *convoluta* gametophytes, 2 gametophytes of the intermediate type (see text), and 2 *normal* gametophytes from a *normal* × *convoluta* perithecium.

the central growth of another *convoluta* culture which had not started secondary growth. The two transfers from the *normal*-type sector yielded apparently *normal* cultures, the four transfers from *convoluta* growth yielded *convoluta* cultures, and the two transfers from the sparse sector yielded an entirely new type of growth (FIG. 4*a*).

The new type of growth was resupinate, produced strong reddish pigmentation of the hyphae and medium, and developed no convolutions at the centers of the cultures. The initial growth-rate of these cultures was intermediate between that of the *convoluta* and *normal* types, but due to rapid staling they were soon surpassed

by the secondary growth of the *convoluta* cultures (FIG. 4*a*). No further study of this strain was made.

Twenty-four single-ascospores were isolated from a *normal* (*a*) × *convoluta* (*A*) perithecium. Twelve of these developed *normal* cultures, six developed *convoluta* cultures, and six developed cultures differing from the *normal* type in the possession of a slightly slower growth-rate, in the development of a grey-green cast, and in the lack of the tan macrospore masses over the inoculum which form so conspicuous a feature of all *normal* cultures (FIG. 4*b*). The high percentage of cultures of this type and their uniformity suggest Mendelian recombination. Sex-reaction factor determinations showed the following distributions:

	normal	*convoluta*	new type
A:	8	5	4
a:	4	1	2

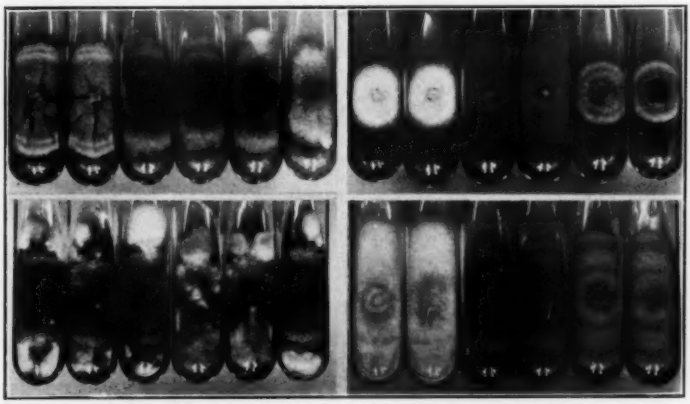
The population is again too small to permit extensive conclusions, but suggests that *convoluta* differs from *normal* by one or more Mendelian factors. No linkage with the sex-reaction genes is evident. Recovery of apparently *normal* cultures from vegetative mycelium of the *convoluta* strain indicates that the gene or genes involved are unstable and capable of reverting to the *normal* state.

THE REVERTA VARIANT

The *reverta* variant developed from a single ascospore in a population of one-hundred and twenty isolated from a *normal* × *aborta* perithecium. The remainder of the spores developed either *normal* cultures or cultures of the *purple* variant previously discussed. The *reverta* type differed from *normal* in an extremely slow growth-rate, a deep red pigmentation of mycelium and medium, a fluting of the colony center, an almost total lack of normal conidia, and a resupinate habit (FIG. 5). Microscopic examination of the hyphae showed them to be composed of short, stout cells which readily became disengaged from one another, thus resembling abnormal conidia. Whether or not true conidia were formed was uncertain; if so, they were very rare and quite abnormal.

It was noted that when the original *reverta* culture was removed

from the 27° C. incubator after five days,[1] growth of *reverta*-type mycelium apparently ceased. The day after removal from the incubator, sectors of apparently *normal* hyphae started from the margin of the *reverta* mycelium (FIG. 5*a*). No further extension



a *b*

FIG. 5. *a*, Upper, 2 *vinifera* cultures on the left, and 4 f, *reverta* gametophytes from a *normal* × *reverta* perithecium on the right. Lower, sectors of "reverted" mycelium appearing in typical *reverta* cultures 6 days after removal from 27° C. chamber. *b*, Left to right: 2 *normal*, 2 *reverta*, and 2 *restricta* gametophytes from a *normal* × *reverta* perithecium. Upper, 3 days old; lower, 7 days old.

of the *reverta* mycelium occurred, but the top and bottom of the slope became covered with *normal* growth. Before extensive development of the reverted sectors had occurred, twelve single-cell (or conidium) cultures were obtained from the *reverta* mycelium. Ten of these were treated exactly as the original *reverta* culture had been treated, and behaved in exactly the same manner, though the growth-rate of the *reverta*-type mycelium varied from tube to tube. The other two cultures were placed in a 23° C. rather than a 27° C. chamber and at the end of two days showed no growth whatever. They were then placed in the 27° C. chamber and growth of *reverta*-type mycelium commenced at once. When re-

[1] Throughout this study all cultures were placed in a 27° C. chamber for the first five or six days of growth and then removed to the laboratory table.

moved to the laboratory table three days later, growth of *reverta* mycelium immediately ceased. One tube was subsequently replaced in the 27° C. chamber and growth of *reverta* mycelium was resumed. Sectors of *normal* mycelium eventually appeared in both tubes.

In another test, five single-cell cultures obtained from a young *reverta* colony were removed from the 27° C. chamber after five days and placed on the laboratory table, while five others were allowed to remain in the incubator. Those removed from the incubator ceased development of *reverta* mycelium and immediately formed *normal*-type sectors, whereas those left in the incubator continued to develop *reverta*-type mycelium until the slopes were covered, weak sectors appearing in only two of the five tubes. In all cases transfers from sectors yielded pure *normal*-type colonies, whereas transfers from *reverta* mycelium in young cultures yielded *reverta* cultures. Eventually, however, reversion became complete throughout the colonies, for numerous attempts to recover the *reverta* type by single-cell or mass transfers from cultures two weeks old were wholly unsuccessful, all transfers yielding pure *normal* cultures.

Back-crosses to the *normal* tester-strains had been made from the original *reverta* culture before extensive development of the reverted sectors. The *normal* mycelium in the matings quickly overgrew the slower *reverta* mycelium, but eventually perithecia were formed in the *normal* $A \times$ *reverta* cross, showing that the *reverta* mycelium possessed sex-reaction factor *a*. Although it was considered probable that the perithecia were formed only after the *reverta* mycelium had reverted to the *normal* type, thirty single-ascospore cultures were made from one of the hybrid perithecia. Of these, fifteen developed cultures of the *reverta* type, thirteen developed cultures of the *normal* type, and two developed cultures of the *restricta* type (FIG. 5*b*). The distribution of sex-reaction factors was found to be as follows:

	normal	*reverta*	*restricta*
A:	4	6	0
a:	9	9	2

The data indicate that the *reverta* phenotype is determined by

one or more Mendelian factors which are sufficiently stable to segregate somewhat normally in the maturation divisions. It is possible that some reversion occurred during meiosis, though this could be proved only by tetrad analysis. All the *reverta* cultures in the back-cross progeny developed sectors of reverted mycelium exactly as had the parent *reverta* isolate and its sub-cultures. Perpetuation of the *reverta* strain would therefore be extremely difficult at room temperature, though the experiments suggest the possibility of perpetuation of the strain by cultivation exclusively at high temperatures. The *reverta* gene or genes are apparently not linked with the sex-reaction genes.

THE RESTRICTA VARIANT

The *restricta* variant, while less striking than some of those previously discussed, is of considerable interest because of its appearance in four different populations. It first appeared as one single-ascospore culture in a population of twenty-six obtained from a *normal* × *aborta* hybrid perithecium. The variant again appeared in the progeny of *normal* × *alba*, *normal* × *albida*, and *normal* × *reverta* back-crosses, one ascospore in each of the first two, and two in the third, yielding cultures indistinguishable from the original *restricta* type. This variant differed from *normal* in the production of silky hyphae which developed an even, reddish pigmentation. The medium soon became somewhat fluted at the center and showed marked restriction of development at the top of the slopes, the agar surface never becoming completely covered (FIGS. 5*b*, 6).

The *restricta* variant was more stable than the other variants in mass-transfer and single-conidium cultures. A white, fluffy sector resembling *normal* appeared in one single-conidium culture, however. Transfers from this sector yielded cultures which varied from the *restricta* type "in the direction" of the *normal*, whereas transfers from *restricta* growth in the same tube yielded typical *restricta* cultures (FIG. 6).

The first observed *restricta* variant was mated with both *normal* tester-strains and found to bear sex-reaction factor *A*. Of twenty-one ascospores isolated from one of the resulting perithecia,

nine developed *normal* and twelve developed *restricta* cultures. Six *normal* and seven *restricta* cultures were found to bear sex-reaction factor *A*, three *normal* and three *restricta* the factor *a*. The sex-reactions of the remaining two *restricta* cultures were not determined.

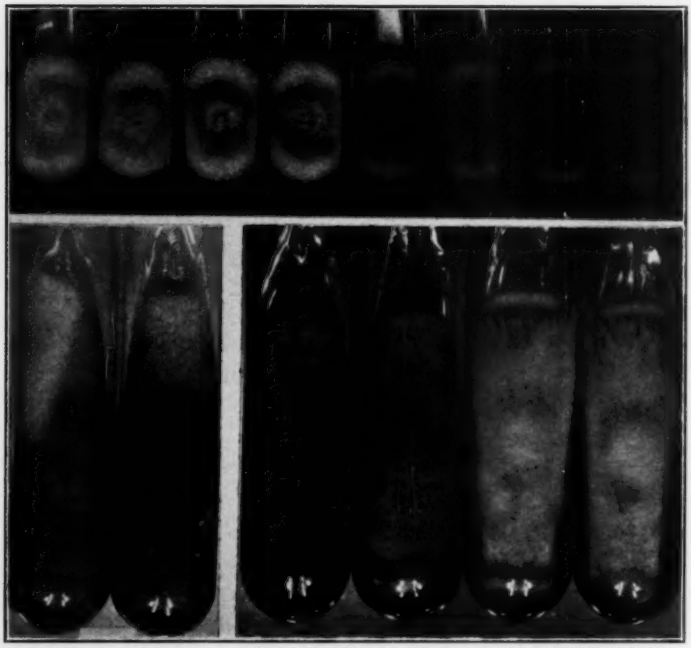


FIG. 6. Upper, 4 four-day-old cultures each of *normal* and *restricta* strains; the 4 central cultures are f_1 gametophytes from a *normal* × *restricta* perithecium. Lower left, sector of "reverted" growth appearing in one of two single-conidium cultures of *restricta*. Lower right, two mass transfers each from the *restricta* growth and from the "reverted" sector in the sectoring culture illustrated.

These data indicate that *restricta* characters are conditioned by one or more Mendelian factors. There appears to be no linkage between the *restricta* factors and the sex-reaction factors. The factor or factors, while relatively stable, are capable of variation toward *normal* in monoploid vegetative cells. The appearance of

this variant in four distinct hybrid perithecia suggests that mutation of the gene from *normal* to *restricta* may occur with some frequency during maturation divisions in hybrid asci.

DISCUSSION ON ASCOSPORE VARIANTS

Several variants of the type considered in this paper have been recorded in the literature. The "albinistic" strain of *Neurospora sitophila* noted by Dodge (**4**, **5**) first appeared as a single-ascospore culture obtained from a perithecium resulting from a mating of his strains Arl. 6 and Arl. 10. Consideration of his papers leads to the opinion that the strain Arl. 10 was heterocaryotic, bearing both "conidial" and "albinistic" nuclei. Both Dodge and Wülker (**8**) have shown that this factor pair segregates at meiosis independent of the factors for sex-reaction.

Lindegren (**6**) studied six variants from the *normal* type in *Neurospora crassa*. The *tan* mutant appeared as a single-ascospore variant in the third inbred generation of the *normal* type. The other five mutants all appeared as ascospore variants in the lineage of a single *normal* × *tan* hybrid ascus. It is noteworthy that the asci yielding the variants were all obtained from perithecia resulting from *normal* × *normal* rather than *normal* × *tan* or *normal* × "variant" crosses. Lindegren attributes only the appearance of the *tan* strain to gene mutation, the remainder presumably resulting from the segregation of preëxisting genes. The *tan* mutant is of considerable interest since Lindegren (**6**, **7**) has shown that the *tan* gene reverts to *normal* with high frequency, both in the vegetative cells and during the maturation divisions. Mutation from *normal* to *tan* was also found to be a recurrent phenomenon, though taking place much less frequently than the back-mutation from *tan* to *normal*. The behavior of this mutant strongly resembles that of the *purple* variant discussed in the present paper.

Zickler (**9**) has made a thorough study of ascospore variants appearing in the progeny of hybrid asci of *Bombardia lunata*. Four such variants came to his attention during analyses of all eight spores in individual asci. Each appeared as the primary growth of two adjacent spores which should have yielded mycelia of one of the parent types. The mutations obviously occurred in one chromatid of the tetrad. The hereditary character of some

of these variants was proved by hybridization studies. Zickler further noted the back-mutation in the heterozygote of a mutant which had first appeared as a sector variant in vegetative mycelium, and whose hereditary nature had been proved. Usually the mutation or back-mutation occurred in but one chromatid of the tetrad, though in two cases mutation of the same gene occurred in both sister chromatids.

Wulker's work (**8**) on the factors for the presence or absence of aerial mycelium in a strain of *Neurospora sitophila* has already been mentioned. Mutation of these genes both in the maturation divisions and in vegetative mycelium occurred with considerable frequency, as was the case with Lindegren's *normal-tan* and the writer's *normal-purple* factor pairs. Wülker, like Zickler (**9**), observed that in maturation divisions mutation in a single chromatid was more frequent than mutation in both sister chromatids, and also that mutation in a single chromatid was more frequent than failure of mutation in both chromatids. To explain this frequent mutation, he proposed three hypotheses: (1) that the cause lies purely in the labile nature of the genes; (2) that the conversion is favored by the simultaneous presence of both members of the allelomorphic pair in the heterozygote; and (3) that the high mutation rate is attributable to the presence of an independent, non-linked "Umschlagfaktor" pair, the presence of the dominant allel *U* in a gamete either suppressing expression of one of the mycelial character factors or favoring or inducing its mutation. Wülker further noted the appearance of an ascospore variant which inhibited ascospore maturation, and of another which caused a striking restriction of mycelial growth.

The experiments outlined in this paper, limited as they were, have strongly indicated that the variants discussed, with the possible exception of *albida*, were the result of true gene mutation. The fact that four of the strains (*purple, albida, convoluta,* and *reverta*) showed apparently complete reversion to *normal* in the monoploid vegetative cells suggests that the mutations have been of the nature of inactivation or alteration of the *normal* or wild-type genes. Had the wild-type genes suffered deletion, reversion to *normal* would be difficult to conceive, particularly in gametophytic cells.

It is significant that although more than one thousand single-conidium and mass-transfer cultures of the *normal* strain have been carefully observed during the work on *Hypomyces Ipomoeae,* only one spontaneous sector variant sufficiently different from *normal* to be detected arose (**3**). Furthermore, neither this variant nor an induced variant (**2**), which also arose in gametophytic cells, has shown any tendency to reversion or further mutation, though more than one hundred and fifty single-conidium and mass-transfer cultures of each have been closely studied. In contrast to this, six distinct and striking variants have appeared as the primary growth of individual isolated ascospores although the number of single-ascospore cultures studied has been less than half the number of single-conidium cultures. Note further that, excluding *purple,* four of the five remaining ascospore variants have appeared only in the progeny of hybrid perithecia, and that all have shown a tendency to reversion, further mutation, or both.

The inference is inescapable that mutation is favored during the stress of the meiotic nuclear divisions. Zickler (**9**) and Wülker (**8**) were likewise, as a result of their studies, forced to this conclusion. The observations of these workers and of the writer suggest, moreover, that mutation is particularly favored in the maturation of heterozygotes. The present studies indicate further that the effect may be carried over into subsequent gametophytic cells, possibly as the result of mitotic abnormalities or unusual stress, leading to reversion or further mutation of the affected gene or genes.

The subject can scarcely be left without a brief consideration of the biological significance of ascospore variants. The following facts concerning these variants have been observed during the course of the work: (1) all have possessed growth-rates slightly or markedly slower than *normal;* (2) all have been poorer in the production of conidia, some being almost non-conidial; (3) with the possible exception of the *alba* variant, all have shown low fertility in back-crosses to *normal,* perithecium formation being either delayed or less abundant; (4) attempts at inbreeding have been entirely unsuccessful to date (save in one *purple* × *purple* mating), neither perithecia nor perithecial fundaments being produced in matings of variant strains bearing opposite sex-reaction

factors; and (5) all have shown either complete reversion to the *normal* or variation "in the direction" of the *normal*. These facts strongly indicate that under the environmental conditions which obtained during the work none of the ascospore variants would long be perpetuated in competition with the *normal* strains. The interesting observations concerning the high temperature requirement for maintenance of the *reverta* variant suggest the possibility that in certain environments the mutant strains might be able to compete successfully with the *normal*.

SUMMARY

A number of variants which cannot well be explained on the basis of Mendelian segregation of preëxisting genes have arisen as the primary growth from single ascospores isolated from both inbred and hybrid perithecia of *Hypomyces Ipomoeae*.

Hybridization studies have shown the variations, with one possible exception, to have been the result of gene mutation.

The reversion of many of these mutants to the *normal* type, both in the maturation divisions and in vegetative cells, indicates that the mutations have been of the nature of inactivation or alteration, rather than deletion, of the genes.

The observations strongly suggest that gene mutation is favored in the maturation divisions—particularly in heterozygotes. Effects of the mutations appear in some cases to be carried over into the gametophytic cells of the mutants.

Evidence is presented which indicates that under existing environmental conditions the ascospore variants studied would not be perpetuated in competition with the *normal* type.

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NOTES AND BRIEF ARTICLES

MYCOLOGICAL SOCIETY OF AMERICA

Fungi Collected at the Foray, August 1938

As has been reported elsewhere (Mycologia **31**: 233–234. 1939) the Mycological Foray for 1938 was held at Duchesnay, Quebec, August 23–27. The weather was specially favorable for the development of fungi and collecting was excellent. On account of the small amount of published information concerning the mycological flora of Quebec it was voted to publish a complete list of the fungi collected during the foray and the undersigned committee was appointed to supervise the preparation of the list.

During the foray 836 species and varieties were collected, an unusual number for such a short period. The following list of species has been compiled from reports submitted by the various collectors. The symbols in parenthesis indicate the sources of the reports.

B = Henry C. Beardslee, Altamonte Springs, Fla.
Be = Ernst A. Bessey, Michigan State College.
Br = Jules Brunel, Université de Montréal.
C = Cornell University group, combining reports of collections by H. H. Whetzel, Thomas Sproston, and H. M. Fitzpatrick.
G = J. Walton Groves, Ottawa, Ontario.
H = L. K. Henry, Carnegie Museum, Pittsburgh, Pa.
Ha = Robert Hagelstein and Joseph H. Rispaud, New York Botanical Garden.
J = Henry A. C. Jackson, Montreal, Canada.
M = E. B. Mains, University of Michigan.
N = Fred J. Seaver, New York Botanical Garden.
O = L. O. Overholts, Pennsylvania State College.
P = René Pomerleau, Quebec.
S = Walter H. Snell, Brown University.
T = H. S. Jackson and Roy F. Cain, University of Toronto.
W = C. L. Shear, John A. Stevenson, C. W. Emmons, and A. J. Moyer, Washington, D. C.

Myxomycetes: *Arcyria carnea* G. List. (Ha); *A. cinerea* (Bull.) Pers. (Ha); *A. denudata* (L.) Wettst. (G, Ha); *A. ferruginea* Sauter (Ha); *A. incarnata* Pers. (Ha); *A. insignis* Kalchb. & Cooke (Ha); *A. nutans* (Bull.) Grev. (Ha); *A. occidentalis* (Macbr.) List. (Ha); *A. Oerstedtii* Rost. (Ha, T); *A. pomiformis* (Leers) Rost. (Ha); *A. stipata* (Schw.) List. (Ha); *Badhamia affinis* Rost. (Ha); *B. lilacina* (Fr.) Rost. (Ha); *B. magna* Peck (Ha); *B. orbiculata* Rex (Ha); *B. rubiginosa* (Chev.) Rost. (Ha); *Ceratiomyxa fruticulosa* (Muell.) Macbr. (Ha);

Cienkowskia reticulata (Alb. & Schw.) Rost. (Ha); *Comatricha aequalis* Peck (Ha); *C. nigra* (Pers.) Schroet. (Ha); *C. pulchella* (Bab.) Rost. (Ha); *C. rubens* List. (Ha); *C. tenerrima* (Curt.) G. List. (Ha); *C. typhoides* (Bull.) Rost. (Ha); *C. typhoides* (Bull.) Rost. var. *similis* (Ha); *Craterium aureum* (Schum.) Rost. (Ha); *C. leucocephalum* (Pers.) Ditm. (Ha, P, T); *C. minutum* (Leers) Fr. (Ha); *Cribraria intricata* Schrad. (Ha); *C. macrocarpa* Schrad. (T); *C. purpurea* Schrad. (Ha); *C. vulgaris* Schrad. (Ha); *Diachea leucopoda* (Bull.) Rost. (Ha); *D. subsessilis* Peck (Ha); *Dictydiaethalium plumbeum* (Schum.) Rost. (Ha); *Dictydium cancellatum* (Batsch) Macbr. (Ha); *Diderma effusum* (Schw.) Morg. (Ha); *D. globosum* Pers. (Ha); *D. hemisphaericum* (Bull.) Hornem. (Ha); *D. ochraceum* Hoffm. (Ha); *D. Sauteri* (Rost.) Macbr. (Ha); *D. spumarioides* Fr. (Ha); *D. testaceum* (Schrad.) Pers. (G, Ha, T); *Didymium anellus* Morg. (Ha); *D. Clavus* (Alb. & Schw.) Rabenh. (Ha); *D. difforme* (Pers.) Duby var. *comatum* (Ha); *D. eximium* Peck (Ha); *D. melanospermum* (Pers.) Macbr. (Ha, T); *D. nigripes* (Link) Fr. (Ha); *D. squamulosum* (Alb. & Schw.) Fr. (Ha); *Enerthenema papillatum* (Pers.) Rost. (Ha); *Fuligo muscorum* Alb. & Schw. (C, Ha); *F. septica* (L.) Weber var. *candida* (Ha); *F. septica* (L.) Weber var. *rufa* (Ha); *Hemitrichia abietina* (Wig.) List. (Ha); *H. clavata* (Pers.) Rost. (Ha); *H. serpula* (Scop.) Rost. (Ha, T); *H. vesparium* (Batsch) Macbr. (Ha); *Lamproderma arcyrionema* Rost. (Ha); *L. scintillans* (Berk. & Br.) Morg. (Ha); *L. violaceum* (Fr.) Rost. (Ha); *Leocarpus fragilis* (Dicks.) Rost. (Br, G, H, Ha, T); *Licea minema* Fr. (T); *Lycogala epidendrum* (L.) Fr. (Ha); *L. exiguum* Morg. (Ha); *L. flavo-fuscum* (Ehrenb.) Rost. (Ha); *Margarita metallica* (Berk. & Br.) List. (Ha); *Mucilago spongiosa* (Leyss.) Morg. (Ha); *Oligonema nitens* (Lib.) Rost. (Ha); *Perichaena chrysosperma* (Currey) List. (Ha); *P. corticalis* (Batsch) Rost. (Ha); *P. depressa* Lib. (Ha); *Physarum aureum* Brandza (Ha); *P. auriscalpium* Cooke (Ha); *P. bogoriense* Racib. (Ha); *P. cinereum* (Batsch) Pers. (Ha); *P. citrinellum* Peck (Ha); *P. confertum* Macbr. (Ha); *P. conglomeratum* Rost. (Ha); *P. contextum* Pers. (Ha, T); *P. contextum* Pers. var. *Mortoni* (Ha); *P. flavicomum* Berk. (Ha); *P. galbeum* Wing. (Ha); *P. globuliferum* (Bull.) Pers. (Ha); *P. lateritium* (Berk. & Rav.) Morg. (Ha); *P. leucopus* Link (Ha); *P. Listeri* Macbr. (Ha); *P. luteolum* Peck (Ha); *P. melleum* (Berk. & Br.) Mass. (Ha); *P. murinum* List. (Ha); *P. notabile* Macbr. (Ha, T); *P. nutans* Pers. (Ha, T); *P. nutans* Pers. var. *leucophaeum* (Ha); *P. oblatum* Macbr. (Ha); *P. penetrale* Rex (Ha); *P. psittacinum* Ditm. (Ha); *P. pulcherrimum* Berk. & Rav. (Ha); *P. pulcherripes* Peck (Ha); *P. pusillum* (Berk. & Curt.) List. (Ha); *P. rubiginosum* Fr. (Ha); *P. sessile* Brandza (Ha); *P. sinuosum* (Bull.) Weinm. (Ha); *P. sulphureum* Alb. & Schw. (Ha); *P. tenerum* Rex (Ha); *P. virescens* Ditm. (Ha); *P. viride* (Bull.) Pers. (Ha); *P. viride* (Bull.) Pers. var. *aurantium* (Ha); *P. Wingatense* Macbr. (Ha); *Stemonitis axifera* (Bull.) Macbr. var. *Smithii* (Ha); *S. fusca* Roth (Ha); *S. trechispora* Macbr. (Ha); *Trichia Botrytis* (Gmel.) Pers. (Ha); *T. contorta* (Ditm.) Rost. (Ha, T); *T. contorta* (Ditm.) Rost. var. *inconspicua* (Ha); *T. decipiens* (Pers.) Macbr. (Ha); *T. erecta* Rex (Ha); *T. favoginea* (Batsch) Pers. (T); *T. persimilis* Karst. (Ha); *T. scabra* Rost. (Ha, T); *T. subfusca* Rex (Ha); *Tubifera Casparyi* (Rost.) Macbr. (Ha); *T. ferruginosa* (Batsch) Gmel. (Ha).

PHYCOMYCETES: *Bremia Lactucae* Regel. (O); *Endogone pisiformis* Link (C, G, M, O, T, W); *Mucor sylvaticus* Hagem (Be); *Pilobolus umbonatus* Buller (T); *Plasmopara Viburni* Peck (C, T); *Pythiomorpha gonapodyoides* Petersen (Be); *Saprolegnia litoralis* Coker (Be); *Synchytrium aureum* Schroet. (Be).

DISCOMYCETES: *Apostemidium Guernisaci* (Cr.) Boud. (T); *Ascobolus carbonarius* Karst. (N); *A. immersus* Pers. (T); *A. viridulus* Phill. & Plowr. (T) *Ascocalyx Abietis* Naumov (G); *Ascophanus carneus* (Pers.) Boud. (T); *A. lacteus* (Cooke & Phill.) Sacc. (T); *Ascotremella faginea* (Peck) Seaver (T); *Belonidium basitrichum* Sacc. (W); *Calycina macrospora* (Peck) Seaver (C, N, O, T, W); *Catinella nigro-olivacea* (Schw.) Durand (C, O); *Cenangium furfuraceum* (Roth) DeNot. (G); *Chlorociboria aeruginosa* (Oed.) Seaver (H, N); *C. versiformis* (Pers.) Seaver (C, N, O, W); *Chlorosplenium aeruginascens* (Nyl.) Karst. (C, O, T, W); *Coryne sarcoides* (Jacq.) Tul. (Br, O, P, T); *Cudonia circinans* (Pers.) Fr. (G, T, W); *C. lutea* (Peck) Sacc. (G, M, N, O, P); *Dasyscypha Agassizii* (Berk. & Curt.) Sacc. (Br, G, H, J, N, O, P, T, W); *D. arida* (Phill.) Sacc. (G); *D. nivea* (Hedw.) Sacc. (N); *Dermatea acerina* (Peck) Rehm (C, G, O); *D. Ariae* (Pers.) Tul. (G, W); *D. balsamea* (Peck) Seaver (Br, G, P, T, W); *D. Cerasi* (Pers.) Fr. (G); *D. molliuscula* (Schroet.) Cash (Br, G, O, T, W); *D. Peckiana* (Rehm) Groves (G); *Durandiella Nemopanthis* (Peck) Groves (G); *Geoglossum alveolatum* Durand (T); *G. glabrum* Pers. (J, M, O, T, W); *G. nigritum* Cooke (T); *Gloeoglossum difforme* (Fr.) Durand (M); *G. glutinosum* (Pers.) Durand (C, N, T); *Godronia Urceolus* var. *confertus* Hone (G); *Godroniopsis Nemopanthis* Groves (G, W); *Helotium citrinum* (Hedw.) Fr. (G, N, O, T, W); *H. epiphyllum* (Pers.) Fr. (O, W); *H. fastidiosum* Peck (C); *H. herbarum* (Pers.) Fr. (W); *H. immutabile* Fuckel (T); *H. phyllophyllum* (Desm.) Karst. (C, T); *H. Scutula* (Pers.) Karst. (C, G, W); *Helvella crispa* (Scop.) Fr. (J); *H. elastica* (Bull.) Fr. (Br); *H. Mitra* L. (Br, G, H, J); *Lamprospora Crec'hqueraultii* (Crouan) Boud. (N); *Lasiobolus equinus* (Müll.) Karst. (T); *Leotia chlorocephala* Schw. (G, J, M, N, P, T, W); *L. lubrica* (Scop.) Pers. (Br, C, G, H, J, N, O, P, T, W); *L. stipitata* (Bosc.) Schroet. (Br, G, H, J, M, O, T); *Macropodia macropus* (Pers.) Fuckel (W); *Microglossum rufum* (Schw.) Underw. (J, N, W); *Mitrula irregularis* (Peck) Durand (G); *Mollisia uda* (Pers.) Gill. (W); *Ombrophila lilacina* (Wulf.) Karst. (T); *Orbilia botulispora* Höhn. (T); *O. epipora* Karst. (T); *Otidea grandis* (Pers.) Mass. (Br, N, W); *O. leporina* (Batsch) Fuckel (G, H, O, T); *Patella albida* (Schaeff.) Seaver (G, W); *P. coprinaria* (Cooke) Seaver (N, T, W); *P. gregaria* (Rehm) Seaver (T); *P. ovilla* (Peck) Seaver (T); *P. scutellata* (L.) Morg. (H, N, O, P, T, W); *Paxina fusicarpa* (Ger.) Seaver (C); *P. hispida* (Schaeff.) Seaver (Br, C, G, H, J, O); *Pezicula acericola* (Peck) Sacc. (C, G, H, O, P, T, W); *P. carnea* (Cooke & Ell.) Rehm (G, W); *P. corylina* Groves (G); *P. minuta* Peck (G, T); *P. pruinosa* Farl. (G); *P. rosella* Rehm (G); *Peziza badia* Pers. (Br); *P. brunneoatra* Desm. (H); *Pezizella Lythri* (Desm.) Shear & Dodge (W); *Plicariella murina* (Fuckel) Rehm (T); *Podophacidium xanthomelum* (Pers.) Kavina (C, N, T); *Propolis faginea* (Schrad.) Karst. (G, W); *Ryparobius crustaceus* (Fuckel) Rehm (T); *R. monascus* Mouton (T); *R. sexdecimsporus* (Crouan) Sacc. (T); *Saccobolus depauperatus* (Berk. & Br.) Phill. (T); *S. Kerverni* (Crouan) Boud. (T); (G, H, T); *Spathularia clavata* (Schaeff.) Sacc. (J); *S. velutipes* Cooke & Farl. (O, P, T); *Thecotheus Pelletieri* (Crouan) Boud. (T); *Trichoglossum hirsutum* (Pers.) Boud. (H, T, W); *T. velutipes* (Peck) Durand (M, P); *Tympanis alnea* (Pers.) Fr. (G); *T. fasciculata* Schw. (G, T); *T. Pinastri* Am. auct. (G, W); *T. populina* (Fuckel) Sacc. (W); *T. saligna* Tode (G).

PYRENOMYCETES: *Acrospermum cuneolum* Dearn. & House (O, T); *Bertia*

moriformis (Tode) DeNot. (W); *Bombardia arachnoidea* (Niessl) Cain (T); *B. coprophila* (Fr.) Kirsch. (T, W); *Claviceps microcephala* (Wallr.) Tul. (Be, T, W); *Coniochaeta discospora* (Auersw.) Cain (T); *C. Hansenii* (Oud.) Cain (T); *C. leucoplaca* (Berk. & Rav.) Cain (T); *C. scatigena* (Berk. & Br.) Cain (T); *Cordyceps capitata* L. (W); *C. clavulata* (Schw.) Ellis & Ev. (C, M, N, O, P, T, W); *C. militaris* (L.) Link (Br, C, G, H, J, M, N, O, T, W); *C. ophioglossoides* (Ehrh.) Link. (Br, C, G, H, J, M, N, O, P, T, W); *Cryptospora suffusa* (Fr.) Tul. (G); *Cucurbitaria parasitica* (Pass.) Berl. (W); *Daldinia concentrica* (Bolt.) Ces. & DeNot. (J, W); *D. vernicosa* (Schw.) Ces. & DeNot. (Br, H); *Delitschia bisporula* (Crouan) Hans. (T); *D. didyma* Auersw. (T); *D. Marchalii* Berl. & Vogl. (T); *D. timagamensis* Cain (T); *Dialonectria sanguinea* (Bolt.) Cooke (T); *Diaporthe impulsa* (C. & P.) Sacc. (G, W); *D. tessera* (Fr.) Fuckel (W); *Diatrype Stigma* (Hoff.) DeNot. (W); *D. virescens* (Schw.) Ellis & Ev. (N, W); *Dibotryon morbosum* (Schw.) Th. & Sy. (G, O, W); *Dothiora Sorbi* (Wahlbg.) Rem. (W); *Erysiphe Galeopsidis* DC. (O); *Eutypella Sorbi* (Schm.) Sacc. (G); *Fenestella vestita* (Fr.) Sacc. (W); *Gelasinospora tetrasperma* Dowding (T); *Gnomoniella Coryli* (Batsch) Sacc. (Be, M, T, W); *Hypocrea aurantiaca* Peck (G); *H. citrina* (Pers.) Fr. (T); *H. patella* Cooke & Peck (G, N, W); *H. pulvinata* Fuckel (T); *H. rufa* (Pers.) Fr. (O, T, W); *Hypocreopsis lichenoides* (Tode) Seaver (T); *Hypomyces apiculatus* (Peck) Seaver. (C, M, W); *H. chrysospermus* (Bull.) Tul. (O); *H. hyalinus* (Schw.) Tul. (J, O, P); *H. Lactifluorum* (Schw.) Tul. (Br, C, G, H, J, N, O, T); *Hypoxylon caries* (Schw.) Sacc. (W); *H. cohaerens* (Pers.) Fr. (P, T, W); *H. fuscum* (Pers.) Fr. (W); *H. deustum* (Hoffm.) Grév. (T); *H. multiforme* Fr. (N, O, W); *H. rubiginosum* (Pers.) Fr. (T); *H. serpens* (Pers.) Fr. (T); *Lasiosphaeria hirsuta* (Fr.) Ces. & DeNot. (T); *L. muscicola* DeNot. (T); *L. ovina* (Pers.) Ces. & DeNot. (T); *L. Sphagni* Delacr. (C, W); *Leptosphaeria lycopodiicola* (Peck) Sacc. (W); *L. subconica* (Cooke & Peck) Sacc. (W); *Leptospora canescens* (Pers.) Wint. (T); *Linospora* sp. (C); *Lophiostoma triseptatum* Peck (W); *Lophiotricha viridicoma* (Cooke & Peck) Kauff. (T); *Melanomma pulvispyrius* (Pers.) Fuckel (W); *Mycosphaerella colorata* (Peck) Earle (Be); *Nectria cinnabarina* (Tode) Fr. (G, O, T, W); *N. Cucurbitula* Sacc. (G); *N. ditissima* Tul. (Br); *Nummularia discreta* Schw. (W); *Perisporium vulgare* Corda (T); *Phaeocryptopus nudus* (Peck) Petr. (G, O, T, W); *Phomatospora hyalina* (Griff.) Cain (T); *Podosphaeria Oxyacanthae* (DC.) deBary (Be); *Rosellinia mammiformis* (Pers.) Ces. & DeNot. (G); *R. pulveracea* (Ehr.) Fuckel (W); *Scoleconectria balsamea* (Cooke & Peck) Seaver (W); *S. scolecospora* (Bref.) Seaver (W); *Sordaria appendiculata* Auersw. (T); *S. anserina* (Ces.) Wint. (T); *S. araneosa* Cain (T); *S. barbata* Hans. (T); *S. carbonaria* (Phill. & Plowr.) Sacc. (T); *S. cervina* Cain (T); *S. curvicolla* Wint. (T); *S. curvula* deBary (T); *S. decipiens* Wint. (T); *S. dubia* Hans. (T); *S. fimicola* (Rob.) Ces. & DeNot. (T); *S. fimiseda* Ces. & DeNot. (T); *S. glutinans* Cain (T); *S. leporina* Cain (T); *S. macrospora* Auersw. (T); *S. minima* Sacc. & Speg. (T); *S. minuta* Fuckel (T); *S. perplexens* Cain (T); *S. pleiospora* Wint. (T); *S. setosa* Wint. (T); *S. tetraspora* Wint. (T); *S. vestita* Zopf (T); *S. zygospora* Speg. (T); *Sporormia ambigua* Niessl (T); *S. bipartis* Cain (T); *S. intermedia* Auersw. (T); *S. leporina* Niessl (T); *S. longispora* Cain (T); *S. minima* Auersw. (T); *S. muskokensis* Cain (T); *S. obliquisepta* Speg. (T); *S. octomera* Auersw. (T); *S. splendens* Cain (T); *Ustulina vulgaris* Tul. (P, W); *Valsa Abietis* Fr. (T, W); *V. nivea* (Hoff.)

Fr. (O); *Xylaria castorea* Berk. (T); *X. corniformis* Fr. (G); *X. filiformis* (Alb. & Schw.) Fr. (C, T, W); *X. longipes* Nitsch. (T); *X. polymorpha* (Pers.) Grév. (Br, J, O, P, W).

OTHER ASCOMYCETES: *Agyrium rufum* (Pers.) Fr. (W); *Coccomyces coronatus* (Schw.) Rehm (C); *Cryptomyces Pteridis* (Reb.) Rehm (Br, C, P, W); *Dimerosporium pulchrum* Sacc. (W); *Elaphomyces muricatus* Fr. (T); *E. variegatus* Vitt. (C, P); *Hypoderma rufilabrum* (Berk. & Curt.) Duby (O); *Onygena equina* Pers. (Br, G, J, W); *Propolis faginea* (Schrad.) Karst. (N); *Rhytisma acerinum* (Pers.) Fr. (W); *R. Andromedae* (Pers.) Fr. (M); *R. Ilicis-canadensis* Schw. (Br, C, G, O); *R. salicina* (Pers.) Fr. (N, O, W); *R. Vaccinii* (Schw.) Fr. (W); *Taphrina Robinsoniana* Gies. (C, G, W).

LOWER BASIDIOMYCETES: *Auricularia Auricula-Judae* (Fr.) Schroet. (Br, C, G, H, O, P, W); *Calocera cornea* (Batsch.) Fr. (H, O, P, W); *Dacryomyces aurantius* (Schw.) Farl. (H, W); *D. Ellisii* Coker (O); *D. palmatus* (Schw.) Bres. (J, O, P, T); *Exidia glandulosa* (Bull.) Fr. (O, T); *E. recisa* (Bull.) Fr. (W); *Exobasidium Vaccinii* (Fuckel) Wor. (C); *Femsjonia luteoalba* Fr. (Br, H, O, T, W); *Guepinia Peziza* Tul. (O); *Heterochaetella dubia* Bourd. & Galz. (T); *Hormomyces fragiformis* Cooke (O, W); *Naematelia nucleata* (Schw.) Fr. (O, P, T); *Pilacrea faginea* (Fr.) Berk. & Br. (C, O, P, W); *Sebacina caesio-cinerea* (Höhn. & Litsch.) Rogers (T); *S. Eyrei* Wakef. (T); *S. incrustans* (Pers.) Tul. (Br, H); *S. sublilacina* Martin (T); *Tremella foliacea* var. *succinea* (Pers.) Neuh.? (T); *T. frondosa* Fr. (G, O); *Tremellodendron candidum* (Schw.) Atk. (H); *T. merismatoides* (Schw.) Burt (W); *T. pallidum* (Schw.) Burt (O, T); *Tremellodon gelatinosum* (Scop.) Fr. (Br, C, G, H, J, O, T, W); *Tulasnella pruinosa* Bourd. & Galz. (T).

USTILAGINALES AND UREDINALES: *Calyptospora Goeppertiana* Kühn (Be, Br, C, H, M, O); *Chrysomyxa Cassandrae* (Peck & Clin.) Tranz. (M); *C. Pyrolae* (DC.) Rostr. (M); *Cintractia externa* (Griff.) Clint. (W); *Coleosporium Solidaginis* (Schw.) Thuem. (M, W); *Melampsora Abieti-capraearum* Tub. (O, W); *M. Ribesii-purpureae* Kleb. (W); *Melampsorella Cerastii* (Pers.) Schroet. (Br, J, T, W); *Puccinia Circaeae* Pers. (T); *P. extensicola* Plowr. (W); *P. Heucherae* (Schw.) Dietel (O); *P. porphyrogenita* Curt. (G, O, W); *P. Violae* (Schum.) DC. (C, O); *Pucciniastrum Agrimoniae* (Schw.) Tranz. (O); *P. Epilobii* Otth (Be, O, T, W); *Sphacelotheca Hydropiperis* (Schum.) deBary (C); *Uredinopsis macrosperma* (Cooke) Magn. (Be); *U. Osmundae* Magn. (C, M, O, T, W); *U. mirabilis* (Peck) Magn. (W); *Uromyces Junci* (Desm.) L. Tul. (W).

THELEPHORACEAE: *Aleurodiscus acerinus* (Pers.) Höhn. & Litsch. (O); *A. acerinus alliaceus* (Quél.) Bourd. & Galz. (T); *A. amorphus* (Pers.) Rabenh. (C, G, O, T, W); *A. canadensis* Jackson (O); *A. Farlowii* Burt (G, M, O, T); *A. griseo-canus* (Bres.) Höhn. & Litsch. (T); *A. penicillatus* Burt (T); *Coniophora cerebella* Pers. (T); *Corticium anceps* (Bres. & Syd.) Gregor (C, O, P, T); *C. bombycinum* (Sommerf.) Bres. (T); *C. centrifugum* (Lév.) Bres. (T); *C. confine* Bourd. & Galz.? (T); *C. confluens* Fr. (T); *C. coronatum* (Schroet.) Höhn. & Litsch. (T); *C. coronilla* Höhn. (T); *C. crustaceum* (Karst.) Höhn. & Litsch. (T); *C. deflectens* Karst.? (T); *C. flavescens* (Bon.) Wint. (T); *C. galactinum* (Fr.) Burt (O, T); *C. hydnans* (Schw.) Burt (G, T); *C. investiens* (Schw.) Bres. (Br, O, P); *C. laeve* Pers. (T); *C. microsporum* (Karst.) Bourd. & Galz. (T); *C. porosum* Berk. & Curt. (T); *C. roseocremeum* Bres. (T); *C. roseum*

Pers. (G); *C. sphaerosporum* Maire? (T); *C. stellulatum* Bourd. & Galz. (T); *C. subcoronatum* Höhn. & Litsch. (T); *C. subpallidulum* Litsch. (T); *C. vagum* Berk. & Curt. (T); *Craterellus clavatus* Pers. (T); *C. cristatus* Kauff. (O, T); *C. lutescens* (Pers.) Fr. (H); *C. taxophilus* Thom (Br, C, J, M, O, P, W); *Cyphella arachnoidea* Peck? (T); *C. fasciculata* (Schw.) Berk. & Curt. (G, O, T); *Cytidia salicina* (Fr.) Burt (G, T); *Gloeocystidium furfuraceum* (Bres.) Höhn. & Litsch. (T); *Hymenochaete agglutinans* Ellis (T, W); *H. arida* Karst.? (T); *H. corrugata* (Fr.) Lév. (O, T); *H. rubiginosa* (Dicks.) Lév. (H); *H. tabacina* (Sow.) Lév. (Br, O. P, T, W); *Hypochnus fumosus* Fr. (T); *H. isabellinus* Fr. (T); *H. umbrinus* (Fr.) Burt (T); *Peniophora affinis* Burt (T); *P. argillacea* Bres. (T); *P. aurantiaca* Bres. (O, T); *P. byssoidea* (Pers.) Höhn. & Litsch. (T); *P. carnosa* Burt (T); *P. cinerea* (Pers.) Cooke (O, T); *P. gigantea* (Fr.) Mass. (T); *P. glebulosa* Bres. (G, T); *P. laevigata* (Fr.) Mass. (O); *P. laevis* (Fr.) Höhn. & Litsch. (T); *P. longispora* (Pat.) Höhn. (T); *P. miniata* (Berk.) Burt (G); *P. nuda* (Fr.) Bres. (T); *P. pallidula* Bres. (T); *P. pubera* (Fr.) Sacc. (T); *P. Sambuci* (Pers.) Burt (T); *P. sanguinea* (Fr.) Bres. (T); *P. sordidella* Höhn. & Litsch. (T); *P. tenue* (Pat.) Mass.? (T); *P. viticola* (Schw.) Höhn. & Litsch. (T); *Stereum fasciatum* Schw. (Br, G, H, O, T, W); *S. Murrayi* (Berk. & Curt.) Burt (O, T, W); *S. roseo-carneum* (Schw.) Fr. (G, O, T); *S. rufum* Fr. (W); *S. sanguinolentum* Alb. & Schw. (G, J, O, P, T, W); *Thelephora intybacea* (Pers.) Fr. (H, T, W); *T. multipartita* Schw. (O, T); *T. palmata* (Scop.) Fr. (Br, C, G); *T. terrestris* (Ehrh.) Fr. (T).

CLAVARIACEAE: *Clavaria apiculata* Fr. (H); *C. appalachiensis* Coker (G, O); *C. contorta* (Holmsk.) Fr. (O); *C. cristata* (Holmsk.) Fr. (Br, G, H, O, P, T); *C. crocea* (Pers.) Fr. (H, J, O); *C. flava* Schaeff. (H); *C. formosa* Pers. (T); *C. fusiformis* Sowerby (Br, G, H, O, T, W); *C. helveola* (Pers.) Fr. (O); *C. Kunzei* Fr. (Br, H, O, P, T); *C. ligula* (Schaeff.) Fr. (Br, H, O, P, W); *C. longicaulis* Peck. (J, O, P); *C. mucida* Pers. (J); *C. muscoides* L. (G, J, O, T); *C. ornatipes* Peck (H, O, P, T); *C. pistillaris* (L.) Fr. (O); *C. pulchra* Peck (O, T); *C. stricta* (Pers.) Fr. (H, J, O); *Physalacria inflata* (Schw.) Peck (C, J, O, P, T, W); *Pistillaria clavulata* Ellis (W).

HYDNACEAE: *Asterodon ferruginosum* Pat. (O, T); *Hydnum albo-nigrum* Peck (B, J, W); *H. cyaneotinctum* Peck (B, Br, O); *H. ferrugineum* Fr. (B); *H. graveolens* Delast. (T); *H. imbricatum* (L). Fr. (B); *H. laciniatum* Leers. (O, W); *H. ochraceum* (Pers.) Fr. (Br, G, H, J, O, P, T, W); *H. repandum* Fr. (B, Br, G, H, O, W); *H. scrobiculatum* Fr. (B, H, P); *H. vellereum* Peck (B, O, W); *H. zonatum* (Batsch) Fr. (B, G, H, J, O, T, W); *Mucronella aggregata* Fr. (T); *Odontia alutacea* (Fr.) Bourd. & Galz. (T); *O. aspera* (Fr.) Bourd. & Galz. (T); *O. bicolor* (Alb. & Schw.) Bres. (T); *O. crustosa* (Fr.) Quél. (O, T); *O. fusco-atra* (Fr.) Bres. (T); *O. hydnoides* (Cooke & Mass.) Höhn. (T); *O. pruinosa* Bres. (T); *Phlebia merismoides* Fr. (O).

BOLETACEAE: *Boletinus pictus* Peck (H, J, O, S, T, W); *Boletus americanus* Peck (J. S); *B. badius* Fr. (J, O, S); *B. castaneus* (Bull.) Fr. (J, O, P, S); *B. chromapes* Frost (J, S); *B. chrysenteron* (Bull.) Fr. (G, J, S, T); *B. cyanescens* (Bull.) Fr. (Br, G, H, J, O, P, S, W); *B. edulis* (Bull.) Fr. (Br, H, J, O, S); *B. felleus* (Bull.) Fr. (Br, J, S, T); *B. gracilis* Peck (S); *B. granulatus* (L.) Fr. (G, J, H, S); *B. indecisus* Peck (G, J, S); *B. niveus* Fr. (S); *B. piperatus* (Bull.) Fr. (Br, G, H, J, S, T); *B. placidus* Bon. (H, J, S); *B. rubinellus* Peck (Br, H, J, O, S, T); *B. scaber* (Bull.) Fr. (Br, G, H, J, S, T); *B. subglabripes* Peck

(H, J, S, T); *B. subtomentosus* (L.) Fr. (Br, G, O, S, T); *B. versipellis* Fr. (H, J, S, T); *B. viscidus* Fr. (J, S); *Strobilomyces strobilaceus* (Scop.) Berk. (G, J, S).

POLYPORACEAE: *Daedalea confragosa* (Bolt.) Fr. (Br, G, H, O, W); *D. unicolor* (Bull.) Fr. (Br, G, H, W); *Favolus canadensis* Kl. (Br, O, P); *Fomes annosus* (Fr.) Cooke (Br, O, P); *F. applanatus* (Pers.) Gill. (Br, H, W); *F. conchatus* (Pers.) Karst. (Br, O); *F. connatus* (Weinm.) Gill. (Br, G, H, J, O, P, T, W); *F. fomentarius* (L.) Gill. (Br, H, W); *F. igniarius* (L.) Gill. (Br, G, W); *F. igniarius* var. *laevigatus* (Fr.) Overh. (Br, O, P, W); *F. Pini* (Thore) Karst. (W); *F. Pini* var. *Abietis* (Karst.) Overh. (O); *F. pinicola* (Sw.) Cooke (Br, O, W); *F. subroseus* (Weir) Overh. (O); *Lenzites betulina* (L.) Fr. (W); *L. saepiaria* (Wulf.) Fr. (C, G, H, O, T, W); *Merulius ceracellus* Berk. & Curt.? (T); *M. fugax* Fr. (T); *M. niveus* Fr. (T); *M. tremellosus* (Schrad.) Fr. (O, P, W); *Polyporus abietinus* (Dicks.) Fr. (Br, H, O, P, W); *P. adustus* (Willd.) Fr. (H); *P. albellus* Peck (Br, H, J, O, P, W); *P. balsameus* Peck (Br); *P. betulinus* (Bull.) Fr. (G, H, O, T); *P. brumalis* (Pers.) Fr. (P); *P. caesius* (Schrad.) Fr. (O); *P. cinnabarinus* (Jacq.) Fr. (Br, H, O); *P. cinnamomeus* (Jacq.) Sacc. (G, O); *P. circinatus* Fr. (C, G); *P. cristatus* (Pers.) Fr. (W); *P. elegans* (Bull.) Fr. (Br, H, P, T, W); *P. focicola* Berk. & Curt. (O); *P. fumidiceps* Atk. (H); *P. galactinus* Berk. (G, O); *P. glomeratus* Peck (H, O, T, W); *P. guttulatus* Peck (H, O); *P. hirtus* Quél. (J, O, T); *P. hirsutus* (Wulf.) Fr. (Br); *P. nidulans* Fr. (O, W); *P. pargamenus* Fr. (Br, H, W); *P. perennis* (L.) Fr. (C, H, T, W); *P. picipes* Fr. (G, H, O, W); *P. planellus* (Murr.) Overh. (W); *P. pubescens* (Schum.) Fr. (Br, J, P); *P. resinosus* (Schrad.) Fr. (H, O, T); *P. resinosus* var. *benzoinus* Overh. (G); *P. Schweinitzii* Fr. (C, G, O, W); *P. semipileatus* Peck (G, O, P, T); *P. semisupinus* Berk. & Curt. (G, O, P, T, W); *P. tephroleucus* Fr. (H); *P. Tulipiferae* (Schw.) Overh. (Br, H, O, W); *P. versicolor* (L.) Fr. (Br, H, W); *Poria candidissima* (Schw.) Cooke (T); *P. corticola* (Fr.) Cooke (H, J, T); *P. ferrea* Pers. (O); *P. ferruginosa* (Schrad.) Fr. (J, T, W); *P. fimbriata* (Pers.) Overh. (O); *P. lenis* Karst. (O); *P. medullapanis* (Pers.) Cooke (T); *P. nigrescens* Bres. (O); *P. prunicola* (Murr.) Sacc. & Trott. (O); *P. punctata* Fr. (H, O); *P. rufa* (Schrad.) Fr. (T); *P. selecta* Karst. (T); *P. spissa* Schw. (T); *P. subacida* (Peck) Sacc. (G); *Solenia anomala* (Pers.) Fuckel. (W); *S. candida* (Hoffm.) Fr. (O); *Trametes heteromorpha* (Fr.) Lloyd (Br, C, O); *T. mollis* (Sommerf.) Fr. (O, P, W).

AGARICACEAE: *Amanita brunnescens* Atk. (B); *A. flavoconia* Atk. (Br, G, H, O, T); *A. Frostiana* Peck (B); *A. muscaria* (L.) Fr. (B, G, H); *A. phalloides* Fr. (Br, J); *A. rubescens* Fr. (B, Br, O); *A. verna* Fr. (B, Br); *Amanitopsis strangulata* Fr. (J); *A. vaginata* var. *fulva* Sacc. (B, Br, H, O, W); *A. vaginata* var. *livida* Peck (H); *Armillaria mellea* Fr. (B); *Cantharellus aurantiacus* Fr. (H, J, O); *C. cibarius* Fr. (Br, G, H, J, O, W); *C. clavatus* Fr. (G, J, O); *C. floccosus* Schw. (G, H, J, P); *C. infundibuliformis* (Scop.) Fr. (Br, G, H, J, O, P); *C. umbonatus* Fr. (G, J, P); *Clitocybe albissima* Peck (J, O, P); *C. catina* Fr. (H); *C. clavipes* Fr. (G, H, J, O); *C. decora* Fr. (B, G); *C. ectypoides* Peck (B, G, H, J, O); *C. infundibuliformis* (Schaeff.) Fr. (Br, G, H, J, O); *C. laccata* (Scop.) Fr. (Br, H, O, P); *C. ochropurpurea* Berk. (W); *C. odora* (Bull.) Fr. (G, H, J, O); *Clitopilus novaboracensis* Peck (O); *C. orcellus* Fr. (H, O); *C. prunulus* Fr. (O); *Collybia abundans* Peck (B, Br, G, H, J, O, P); *C. acervata* Fr. (B, G, J, P); *C. butyracea* Fr. (Br, H, P); *C. cirrhata* Fr. (H, J, W); *C. colorea*

Peck (H, J, P); *C. confluens* Fr. (B, Br, H, J, O, W); *C. dryophila* (Bull.) Fr. (B, H, J, O, P); *C. familia* Peck (B); *C. platyphylla* Fr. (B, Br, H, O); *C. radicata* (Relh.) Fr. (B, Br, G, J, O, P, W); *C. radicata* var. *furfuracea* Peck (H); *C. succosa* Peck (B); *C. tuberosa* Fr. (B, Br, G, H, J, O, P, T, W); *Coprinus micaceus* Fr. (H, J); *Cortinarius alboviolaceus* Fr. (Br, G, J, P); *C. anomalus* Fr. (O); *C. armillatus* Fr. (Br, G, H, O); *C. cinnabarinus* Fr. (G); *C. cinnamomeus* Fr. (G, H, J); *C. distans* Peck (H); *C. mammosus* Kauff. (H); *C. sanguineus* Fr. (H, J); *C. semisanguineus* (Fr.) Kauff. (H, J); *C. violaceus* (L.) Fr. (G, H, J, O, P, T); *Crepidotus fulvotomentosus* Peck (H); *C. malachius* Berk. & Curt. (O); *Entoloma salmoneum* Peck (B, G, J, T); *E. speculum* Fr. (G); *E. cuspidatum* Peck (B); *E. sericellum* Fr. (B); *E. strictius* (Peck) Sacc. (G, H, J, O); *Flammula geminella* Peck (G, H, J, O); *F. fusa* (Batsch) Fr. (B); *F. sapinea* Fr. (B); *F. spumosa* Fr. (G, T); *Galera hypnorum* Fr. (H); *Hygrophorus Cantharellus* Schw. (G, H); *H. ceraceus* Fr. (H, J); *H. conicus* (Scop.) Fr. (B, G, O); *H. cuspidatus* Peck (B); *H. marginatus* Peck (B, Br, G, H, O, P); *H. miniatus* Fr. (Br, J); *H. nitidus* Berk. & Curt. (G, H, J); *H. pallidus* Peck (B, J); *H. Peckii* Atk. (H); *H. pratensis* Fr. (B, H); *H. psitticinus* Fr. (G); *H. puniceus* Fr. (G, J); *H. unquinosus* Fr. (H); *Hypholoma sublateritium* (Bull.) Fr. (O, P); *Inocybe geophylla* Fr. (B); *I. Hystrix* Fr. (B, J, O); *I. lacera* (Fr.) Karst. (H); *I. leptophylla* Atk. (O); *Lactarius affinis* Peck (Br, G, H, O); *L. camphoratus* (Bull.) Fr. (B, Br, G, H, O, P); *L. chrysorheus* Fr. (B, G); *L. cilicioides* Fr. (B); *L. deceptivus* Peck (B, Br, G, O, T); *L. deliciosus* (L.) Fr. (G, H, J, O); *L. fuliginosus* Fr. (H, O); *L. Gerardii* Peck (G, O); *L. glyciosmus* Fr. (O); *L. griseus* Peck (B, Br, G, H, J, O, P); *L. helvus* Fr. (B, P); *L. hygrophoroides* Berk. & Curt. (B, H, O, P); *L. lignyotus* Fr. (B, Br, G, H, O, T); *L. luteolus* Peck (G, O, T); *L. mucidus* Burl. (H, P); *L. pyrogalus* Fr. (H, J); *L. representaneus* Britz. (B); *L. rufus* (Scop.) Fr. (O); *L. scrobiculatus* Fr. (J, O); *L. subdulcis* Peck (B, Br, G, H, J, O, P); *L. theiogalus* Fr. (Br, G, H, O); *L. torminosus* Fr. (G, H); *L. trivialis* Fr. (B, G); *L. turpis* Fr. (B, Br, G, H, J, O, P, T); *L. uvidus* Fr. (G, H); *L. vellereus* Fr. (H, O, P); *L. volemus* Fr. (B); *Lentinus cochleatus* Fr. (Br, O, T); *L. haematopus* Berk. (B, J); *L. lepideus* Fr. (G, H, O, W); *L. ursinus* Fr. (W); *Lepiota acerina* Peck (G, J); *L. acutaesquamosa* Fr. (B, G, J); *L. clypeolaria* Fr. (B, Br, G, J, O, P, T); *L. cristata* Fr. (B, G, H, J); *L. fuscosquamea* Peck (W); *L. granosa* Morgan. (G, O); *L. procera* Fr. (B); *Leptonia asperella* Fr. (B, G); *L. grisea* Peck (O); L. *serrulata* Fr. (B); *Marasmius foetidus* (Sow.) Fr. (G, H, O); *M. perforans* (Hoffm.) Fr. (W); *M. rotula* (Scop.) Fr. (O); *M. scorodonius* Fr. (H); *M. siccus* Schw. (Br, H, O, P); *Mycena epipterygia* Fr. (P, T); *M. haematopoda* Fr. (W); *M. Leaiana* Berk. (G, H, O, P, T); *M. pelianthina* Fr. (G, J, O); *M. pura* Fr. (Br, H, P); *M. rosella* Fr. (H); *Naucoria centuncula* Fr. (B); *N. triscopoda* Fr. (B); *Nolanea conica* Peck (B, H); *N. juncea* Fr. (B); *N. mammosa* Fr. (B); *Nyctalis asterophora* Fr. (H); *N. parasitica* (Bull.) Fr. (O); *Omphalia campanella* (Batsch) Fr. (B, G, H, O); *O. epichysium* Fr. (B, G); *O. fibula* Fr. (B, Br, H, P); *Panaeolus campanulatus* Fr. (Br); *Panus patellaris* Fr. (O); *P. salicinus* Peck (T); *P. stypticus* (Bull.) Fr. (Br, J, O, P, W); *Paxillus atrotomentosus* Fr. (G, J); *P. involutus* (Batsch) Fr. (B, Br, G, H, J, O, P); *Pholiota caperata* (Pers.) Fr. (H, O); *P. confragosa* (Bull.) Fr. (B, H, O); *P. erinacella* Peck (B); *P. flammans* (Batsch) Fr. (O, T); *P. squarrosoides* Peck (Br, G, H, O, P, W); *Pleurotus applicatus* Fr. (O, W); *P. ostreatus* (Jacq.) Fr. (Br, O); *Pluteus admirabilis* Peck

(B); *P. cervinus* Fr. (B, H, J); *P. granularis* Peck (B, O); *P. leoninus* Fr. (G, O); *P. longistriatus* Peck (B); *P. nanus* Fr. (G); *P. tomentosulus* Peck (B); *Psalliota abruptibulba* Peck (G); *P. comtula* Fr. (B); *P. diminutiva* Peck (T); *Psathyra corrugis* Fr. (B); *Russula aeruginea* Lingb. (H); *R. amygdaloides* Kauff. (H); *R. compacta* Peck (B, Br, H); *R. consobrina* Fr. (H); *R. decolorans* Fr. (H); *R. decolorans* var. *rubriceps* Kauff. (H); *R. emetica* Fr. (H); *R. flava* Romell (H, J, O, W); *R. foetens* (Pers.) Fr. (Br, H, O); *R. foetentula* Peck (H); *R. fragilis* Fr. (B, Br, H, P); *R. nigricans* Fr. (B); *R. pectinatoides* Peck (B, H); *R. purpurina* Quél. & Schultz (B, H); *R. sericeo-nitens* Kauff. (G, J); *R. sordida* Peck (H, J, P); *R. squalida* Peck (H); *R. variata* Banning & Peck (B); *Schizophyllum commune* Fr. (W); *Tricholoma albiflavidum* Peck (G, O); *T. sejunctum* Fr. (B, G, J); *Trogia crispa* Fr. (Br, G, H, J, O, P, T, W); *Tubaria inquilina* (Fr.) W. S. Smith (B).

GASTEROMYCETES: *Cyathus striatus* Willd. (Br, C, G, H, O, T, W); *Lycoperdon atropurpureum* Vitt. (W); *L. coloratum* Peck (B, O); *L. gemmatum* (Batsch) Fr. (Br, H, O, P); *L. Peckii* Morgan (T); *L. pedicellatum* Peck (B); *L. pyriforme* Schaeff. (Br, H, W); *L. umbrinum* Pers. (W); *Scleroderma aurantium* (Vaill.) Pers. (Br, J, O, P, T, W); *Sphaerobolus stellatus* (Tode) Pers. (Br, C, H, O, W).

FUNGI IMPERFECTI: *Cylindrosporium acerinum* (Peck) Dearn. & House (O); *C. saccharinum* Ellis & Ev. (W); *Darluca Filum* (Biv.) Cast. (O); *Discosia artocreas* (Tode) Fr. (C); *Gelatinosporium abietinum* Peck (W); *G. fulvum* Peck (O); *Glomerularia Corni* Peck (O, T, W); *Graphium giganteum* Peck (G, H, J, O, P, W); *Helicoma Mülleri* Corda (G); *Micropera Sorbi* (Fr.) Sacc. (W); *Myrothecium inundatum* (Tode) Fr. (T); *Phoma Maianthemi* Peck (C); *Ramularia Oxalidis* Farl. (Be); *Sepedonium cervinum* (Ditm.) Fr. (T); *Septonema episphaericum* Peck (W); *Septoria canadensis* Peck (Be); *Sphaeronaemella fimicola* Marchal (T); *S. glomerulosporum* Peck (T); *Trichoderma lignorum* (Tode) Harz. (W); *Varicosporium Elodeae* Kegel (Be).

LICHENS: *Bacidia Schweinitzii* (Tuck.) Schneid. (T); *B. suffusa* (E. Fries) Schneid. (T); *Cladonia Floerkeana* (E. Fries) Sommerf. (T); *C. gracilis* (L.) Willd. (T); *Graphis scripta* (L.) Ach. (T); *Icmadophila ericetorum* (L.) Zahlbr. (T); *Lecidea granulosa* (Hoffm.) Ach. (T); *L. peliaspis* (Tuck.) Zahlbr. (T); *L. vernalis* (L.) Ach. (T); *L. viridescens* (Schrad.) Ach.? (T).

In addition, undescribed species are recognized for *Aleurodiscus*, *Corticium*, *Merulius*, and *Tremella* by H. S. Jackson; for *Ascobolus*, *Bombardia*, *Gelasinospora*, *Microthyrium*, and *Phaeociboria* by R. F. Cain; for *Helicobasidium* and *Platygloea* by G. W. Martin; for *Dermatea*, and *Durandiella* by J. W. Groves; for *Septobasidium* by J. N. Couch.

Committee: E. B. MAINS, *Chairman*
L. O. OVERHOLTS
RENÉ POMERLEAU

MONOBOBLEPHARIS TAYLORI, A REMARKABLE SOIL FUNGUS FROM TRINIDAD[1]

Through the kindness of Prof. W. R. Taylor, botanist of the recent Allan Hancock Pacific Expedition, I was able to obtain a number of soil samples from certain Central American and South American localities which were visited by him.

Among the various Phycomycetous fungi which were recovered from water cultures prepared with these dry soil samples, there appeared in material from Trinidad a delicate species of *Monoblepharis* which has proved to be of considerable interest.

From the accompanying description it will be seen that, aside from the small size, there is nothing unusual about the reproductive organs of the fungus. The remarkable feature of this new species is to be found in the behavior of the egg, which, immediately after fusion with the male gamete, emerges from the oogonium and swims away. The single cilium which propels the zygote appears to be that of the male gamete which persists as a functional organ. The zygote after a short period of motility, comes to rest and surrounds itself with a thickened wall.

The small size of the parts and the unique behavior of the zygote mark the fungus as distinct from all known species of the genus.

Monoblepharis Taylori sp. nov.

Mycelium amplum, hyphis tenuibus, flexuosis, ramosis, 2–5 μ dia. intus reticulate vacuolatis; sporangia anguste siliquiformia valde variabilia, 35–65 μ longa, 5–9 μ crassa, basi angustata, 2.5–4 μ crassa, apices hypharum terminantia vel singula vel bina vel post hyphae ramificationem sympodialem quasilateralia; zoosporis ovoideis vel subcylindricis, 7–9 μ longis, 4.5–5.0 μ latis postice cilio quam somate duplo vel triplo longiore praeditis; oogonium primum terminale vel post ramificationem hyphae sympodialem saepe quasilaterale, clavatum vel obpyriforme, apice rotundatum basi anguste cylindricum, 15–17 μ longum, 8–10 μ crassum basi ad diametrum 2–3 μ angustatum, intus maturitate globulos magnos refractivos includens; antheridia hypogena, saepe plura basipetaliter producta, singula ex segmento hyphae hypo-oogonialis atque protrusione rostrata laterali 8–10 μ longa, 4–5 μ lata, constantia; antherozooideis plerumque binis, amoeboideis, postice uniciliatis, ovoideis si natanibus, ca. 5 μ longis, 3 μ latis, per orificiem ad rostri apicem

[1] I am indebted to Prof. H. H. Bartlett for preparing the Latin description of the species.

emergentibus; ova inseminata late ovoidea vel fere sphaerica, 10–13 μ longa, 8–10 μ lata, postice uniciliata, natantia, intus guttulata, globulis magnis refrativis includentia; oosporis in aqua liberis sphaericis, 8–11 μ dia., etiamque guttulatis, membrana paulum incrassata pallide brunnea laevia, germination hucusque ignota.

In agro Oryzae prope viam ex "Port au Spain" ad "Pitch Lake," Trinidad, B. W. I., legit William Randolph Taylor. Coll. April 18, 1939.—F. K. SPARROW, JR.

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[1] This index was prepared by G. M. Miller.

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